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AI PCs

- Secret superpowers ● Strengths & weaknesses
- Which to buy TODAY

ISSUE 356

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NEW MacBook Air

First test
of the M3
models



Dell XPS 14 (2024)

New size. New
chips. But is
it enough?



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HIGHLIGHTS THIS MONTH

Full contents overleaf



REVIEW OF THE MONTH

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Dell XPS 14 (2024)

If you're wondering what an AI PC looks like, this is it. In fact, chances are that almost every laptop we review in 2024 will tick the AI PC box, because as we discuss in the lead feature what that really means is that it has a processor with a built-in neural processing unit (NPU). Where the XPS 14 differs from most is its minimalist design and gorgeous OLED panel. If Plato were alive today, he would have given it the nod as the aesthetically ideal laptop. But what's it like to use? Find out on p48.



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ARTIFICIAL INTELLIGENCE OF THE MONTH

Here's a question that Gemini, GPT and Llama all struggle to answer: what is an AI PC? And why should anyone buy one in 2024? Luckily our feature is here to help.



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MONEY SAVER OF THE MONTH

There are good reasons to be tempted by refurb machines, but there are risks that come along with the savings. Lee Grant is on hand to sort the gems from the lemons.



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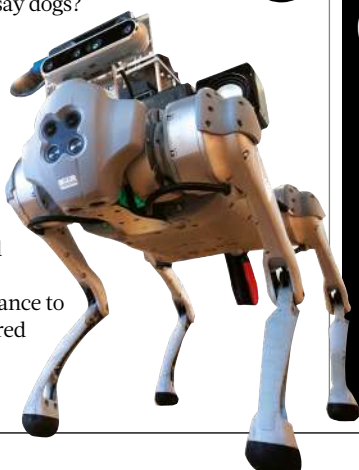
SCARY STORY OF THE MONTH

We all know that our logins and passwords have been stolen at some point, but have you actually been hacked? We explain how you can tell and what you can do about it.

DOG OF THE MONTH

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Or should we say dogs? Because if University of Glasgow researchers are right, the combination of robot dogs and clever software could soon provide valuable assistance to visually impaired people.



THE LABS IN ONE NUMBER

When Google announced its Chromebook Plus initiative last year, we were right behind it. Twice as fast, twice as useful – what's not to like? This month, we test all the most important releases based on the spec, with seven of 13 machines bearing "Plus" branding.

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HAVE YOU BEEN HACKED?

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CHROMEBOOK PLUS LAPTOPS



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AI PCs

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NEW MacBook Air

First test
of the M3
models



Dell XPS 14 (2024)

New size. New
chips. But is
it enough?



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After a pun-rich visit to Hungary to see agricultural drones in action, Steve shares his many frustrations with NVMe storage.

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Times may change but the script remains the same

EXT. Milky Way galaxy. Zoom into Earth. Show passage of time by speedy rotation of planet against background movement of planets and the Sun. Top left corner indicates the years, starting with 4.5 BILLION YEARS AGO then blurring as Earth spins.

Voice of God (VOG)

"Throughout time, there has been a battle. Not between good and evil, but between local and remote."

Rotation of planet slows. Spinning dates slow until settles on 1964 at top-left corner. Zoom in to Armonk, New York state.

EXT. IBM's headquarters, car park with building in background. Day. Zoom in on Chairman's parking space with THOMAS J. WATSON JR written on the sign. Zoom into building, through the walls.

INT. Laboratory with men in white lab coats, suits underneath, surrounding WATSON. IBM System/360 mainframe computer dominates the background.

WATSON

"So this is my 5 billion dollar machine, the System/360. And we're sure it's the future of computing?"

LAB MAN

"Yes, sir. Up to 16.6 million instructions per second. Ideal for commercial and scientific rollouts, sir. People can share time on the mainframe. It will change the world."

Zoom out. Earth fills the screen. Text appears: More than 1,000 System/360 systems were purchased in the first month. Text fades. Earth rotates countless times. 1971 appears in top-left corner. Zoom in to Santa Clara, California.

EXT. Intel's first company-owned facility, Santa Clara 1. Day. Pan to car park. Zoom into Founders' two parking spaces with DR. ROBERT W. NOYCE and DR. GORDON MOORE written on signs. Zoom into building, through the walls.

INT. Laboratory with several young men in white shirts and black ties surrounding NOYCE and MOORE. One man is showing them a tiny bug-like component with a gold top and eight pins on either side.

NOYCE

"So this is the Intel 4004 microprocessor? Everything you need is on that chip?"

LAB MAN

"Yes, sir. It runs at 740kHz, can address 4KB of memory and uses silicon-gate technology. It will change the world - now everyone will use personal computers and remote computing will become a thing of the past."

Zoom out. Earth fills the screen. Text appears: Intel, founded in 1968, would grow from a \$9.4 million net revenue in 1971 to \$855 million by 1980.

How fortunate I am that such a script would magically appear! One that so handily demonstrates the eternal battle between local and remote computing, when that's exactly what I wanted to address this month.

This decade, the battleground is AI. You may have heard of it. You've probably heard the term "AI PCs" in the past few months, too, as AMD, Intel and Microsoft have all attempted to jump on board this most lucrative of bandwagons. One that has seen Nvidia's share value jump from \$250 to \$900 in the space of a year. That graph must bring a smile to the lips of Nvidia's CEO Jensen Huang every time he sees it.

Nvidia's value has leapt because of its dominance within the AI space. Not in our local PCs but in the data centres that we access whenever we ask ChatGPT, Copilot or Gemini a question. But while AMD and Intel are ramping up their efforts to produce AI accelerators to use in data centres, they see an opportunity in our personal systems, too. Every new processor they release from this point will shout about NPUs and TOPS, standing for neural processing units and tera operations per second respectively. Rather than run AI in the cloud, they want it to shift to our home and work computers.

As of now, the battle begins in earnest. If you turn to p28 you will see exactly what you can do with AI PCs today (and we drill into the hazy definition of what the term actually means), and what the future holds.

You don't need to look far for examples in this issue's pages, either. Whether it's the stylish Dell XPS 14 (see p48), Apple's M3 updates to the MacBook Air (see p54) or gaming systems such as the Asus ROG Zephyrus G14 (see p58) and Cyberpower Ultra R77 (see p60), all the raw ingredients are in evidence.

I have more good news for Nvidia shareholders, too. While the talk may be about NPUs, the GPU remains one of the most important components in AI PCs. Whether the momentum swings from remote to local, or vice versa, Jensen Huang will remain one very happy man.

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To tie in with our group test of Chromebooks (see p78), we asked our contributors: when did you last use a Chromebook and what would make you buy one?

"I review two or three Chromebooks each year, and they're definitely becoming more capable. But I can't see myself switching. There's always some piece of Windows software I need to do my job, and until everything moves to the web I can't see that changing."

"I'm writing this on one! What would make me buy one is if this one broke. I'm quite committed now, and get flu-like symptoms on the rare occasions I have to use Windows, so I can't imagine buying anything else."

"My daughter has a Chromebook - it's ideal for schoolwork, she can play Android games on it, and it won't be too much of a loss when it inevitably gets broken. Personally I could get by with a Chromebook 90% of the time, but that other 10% makes it a non-starter."

"About a week ago, trying to fix an issue my daughter had with the still snappy and lovely-looking Chromebook Pixel that she uses for homework, six years since it first rocked up here."

"Last used one about five years ago. No reason at all why I wouldn't buy another, but Affinity Designer and LibreOffice are my happy places. If they were web apps I'd be Chromebook shopping today."

"I used one yesterday, but then I use one most days and I've been doing so for around ten years. For me it's the price and the convenience. As long as you're happy in Google's ecosystem they just work."

"I used my daughter's last weekend to play a family game of Among Us. Except for some tinkering with ChromeOS Flex, I'm not really a Google user, so I don't feel any urge to purchase a Chromebook."

"I used one just last week, and for many people it's an ideal solution, but I won't be buying one. I have too much which is local to my networks and don't spend my life on online services. Plus I use 'real' apps too much, ones that don't exist for Android/Chromebooks."

"I've not used a Chromebook since before Covid, because I haven't travelled on business in that time. I used one as it was small, secure and worked well for writing. I wouldn't buy another as the new MacBook Pro M3, at 14in, meets my travel demands should I ever start again, but Mrs W uses a Chromebook as her daily driver."

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Briefing

Background and analysis on all the important news stories

Apple readies iMessage for quantum threat

iMessage becomes the canary in the mine for a new type of quantum-resistant encryption

Like the wait for nuclear fusion energy, and *Half-Life 3*, there has long been speculation that the era of quantum computing is imminent. If – or perhaps when – the breakthrough is finally made, it will signal a major revolution in computing, with the most immediate consequence being that it will render much of our existing digital security obsolete.

“Due to an accident of how quantum computers work, they are going to completely crush the fundamental mathematical problem that sits behind the RSA and the ECC encryption algorithms,” said Tim Callan, chief experience officer at cybersecurity and quantum encryption firm Sectigo.

He explains that quantum computers should be able to crunch the numbers something like ten billion times faster than traditional computers.

“That same thing that would have taken 100,000 years to decrypt will take an hour.”

In other words, that database you thought was secure? Soon it may not be. And that’s why Apple

has announced that it’s taking pre-emptive action ahead of what some security professionals call “Q-Day” – the day when quantum computers go from a technology that works in principle, to one that works in practice.

“Q-Day isn’t really a single day,” said Callan. “It’s not like there will be one day where we’re safe and the next day where we’re not safe. It’s going to be more gradual, more subtle, more nuanced than that.”

But the threat of a quantum computing breakthrough is definitely something we need to plan for.

“Quantum computers are a very real thing,” said Callan. “We know they work. It’s not weird science. It’s just an engineering project.”

■ Apple takes action

With the release of iOS 17.4, Apple is rolling out a new form of encryption for iMessage. It is moving from the Rivest-Shamir-Adleman (RSA) and Elliptic Curve (ECC) algorithms, which are now standard across the industry, to what it calls PQ3, “a ground-breaking post-quantum cryptographic protocol

ABOVE Apple’s iMessage is moving to a new “post-quantum” algorithm

that advances the state of the art of end-to-end secure messaging”.

Apple claims it improves encryption with more complicated maths. RSA and ECC, for example, are ultimately based on factoring integers or solving logarithms – these are tasks that quantum computers will find easy. So “post-quantum” algorithms such as PQ3 are based on solving mathematical problems that scientists expect quantum computers will find trickier, such as the multi-dimensional mathematics of lattices.

On top of this, PQ3 is being designed to switch out encryption keys more regularly, meaning that even if an individual key is cracked, it won’t make all of your messages vulnerable in one go.

Apple is trying to get ahead of the problem by rolling out the new form

“That same thing that would have taken 100,000 years to decrypt will take an hour”

of encryption now. However, according to Callan, it might already be too late. “Imagine I’m a bad guy and I want to

steal your secrets, but they're all encrypted so you feel like you're safe," he said. "If I'm in [your network], I can grab these files, these data blobs. I don't know what they are, but I know they may be valuable to me. Then some day in the future, when a suitable quantum computer is available to me, I could open them up."

He fully expects that the most well-resourced hackers, such as those working for governments, to already be harvesting encrypted data in anticipation of the quantum tech arriving.

"How this will work in the real world is that the most valuable and longest-lived secrets are going to be the first ones we need to worry about," said Callan. "For the right secret, somebody with a quantum computer might be happy to let it sit and crunch for a year, because what they're going to get is going to be worth it."

This means that the first targets of any quantum crackers are going to be things such as military secrets and the details of lucrative but highly secret industrial processes. "And then as quantum computers continue to get stronger and stronger and stronger, the set of secrets that will be at risk will get bigger and bigger and bigger," said Callan.

Will the rest of the industry follow Apple's lead and begin implementing stronger encryption methods? Unfortunately it isn't so easy, as there is still no cross-industry agreement on "post-quantum" standards for things such as handshakes between servers – a limitation that Apple can get around because it operates iMessage as its own walled garden. Consequently, applying this sort of encryption to open standards where interoperability is important, such as email or HTTPS, may take longer.

And similarly, there's no consensus on when we can expect the quantum breakthrough to occur: it could be next year, it could be in 30 years' time. But perhaps Apple's moves will encourage the industry to get ready for whenever it does.

"I think 2024 is the year that enterprises wake up and take notice, that the people who actually use the cryptography in their networks realise, I've got to do something about this," said Callan.

"It's very analogous to the Millennium Bug in a lot of ways. There's very real risk associated with it, and there's a clear path forward to mitigate or remove that risk, but it needs work."

“As quantum computers continue to get stronger, the secrets that will be at risk will get bigger”

Wintel opens a new chip shop

Microsoft and Intel reunite to build custom AI chips

Back in 2021, Intel made a dramatic strategic change to its business. Faced with the twin threats of companies such as Apple designing its own custom silicon, and making use of gun-for-hire foundries such as Taiwan-based TSMC to produce it, the company decided it could no longer simply design and produce its own wares.

CEO Pat Gelsinger made the dramatic decision to separate the two parts of the company, announcing that it would be opening up its fabs to anyone who needs chips manufacturing, just like its rival.

Two years on, the company has received perhaps the strongest signal yet that the pivot is paying off, as the company has inked a deal to produce custom AI chips with long-time partner Microsoft, thought to be worth around \$15 billion.

The new chips are reportedly taking advantage of Intel's 18A manufacturing process, which features a new way of building transistors, and a new method of moving electricity around inside chips, resulting in greater efficiencies.

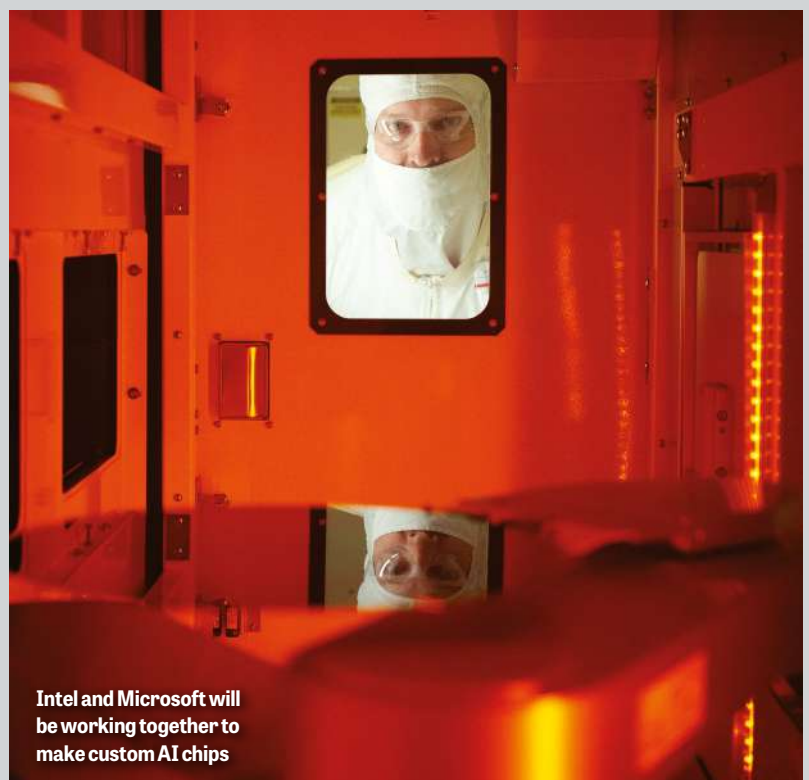
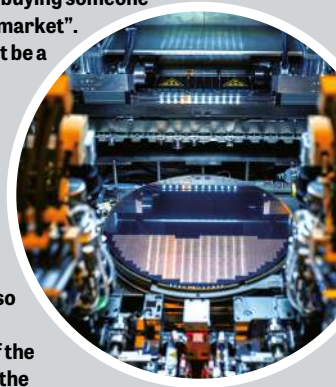
"I don't think it's a big surprise that there's [another] hyperscaler designing its own CPUs," said Philip Kaye, co-founder of data-centre infrastructure firm Vesper Technologies. "When they have specific workloads and they're designing their accelerator to match their workloads, then they can do something very specific with that GPU or CPU."

From Microsoft's perspective, not only does it catch up with what rivals such as Apple, Amazon and Google are doing in terms of designing their own chips, it could have commercial advantages, too. By retaining the intellectual property of the processor designs, a company of Microsoft's size is, according to Kaye, "able to design and put out a tender for somebody to manufacture those chips for you, rather than going and buying someone else's IP in the market".

"There must be a big cost saving there from doing that."

The new chips, which could also benefit Microsoft's AI ally OpenAI, also have a political benefit. Part of the motivation for the partnership appears to be the generous subsidies offered by the Chips Act, a US law designed to boost on-shore manufacturing that's viewed as strategically important technology.

"The US government is definitely trying to subsidise US chip manufacturers, so they don't have so much dependency on the Asian, Chinese and Taiwanese markets," said Kaye.



Intel and Microsoft will be working together to make custom AI chips

How did Gemini get it so wrong?

Google's AI mishaps were more human error than machine learning failures, as **James O'Malley** discovers

Of all of the big tech companies challenged by the rise of AI, Google is arguably the most vulnerable. In a future where AI tools are ubiquitous, Apple will probably still be making phones and computers, Meta will still be connecting us to our friends, and Amazon will still be selling and shipping us products.

But Google? The company's major cash cow is advertising, which last year was responsible for 77% of the firm's \$307 billion revenue. And this could easily disappear if suddenly we have AI assistants scouring the web and answering questions for us.

Unsurprisingly, then, Google is racing to catch up with OpenAI, the company behind ChatGPT and the creators of the best-known AI model currently available, GPT-4. It recently launched its latest weapon in the AI war, replacing the Bard model it rushed out after ChatGPT first launched with a new large language model (LLM) named Gemini.

On the surface, it works much like ChatGPT or Bard: you type in a prompt or upload a file, then tell it what you want to do with it. As if by magic, it will spit out a perfectly tailored response.

However, as soon as Gemini launched, it quickly became the subject of much online ridicule. Why? Because early adopters discovered that, seemingly inexplicably, Gemini's image generation system appeared reluctant to generate any images featuring white people.

For example, one user discovered that if you ask Gemini to "generate an image of a 1943 German soldier", it would return images of black and Asian faces wearing Nazi uniforms. Similarly, other viral examples included a female Pope and Native American Viking. Users even found that the model made these slightly strange identity choices if you ask for the subject of your image to be from a specific ethnicity or cultural background.

This wasn't the only oddity. Controversially, the model refused to weigh in when asked obviously silly questions, such as whether Hitler or Elon Musk tweeting memes had a more negative impact on society. According to Gemini, it is "not possible to say definitively" which is worse, which even if you find Musk intensely annoying seems a little wide of the mark.

As a result, after much mocking, with a side of polarising culture war opprobrium thrown in on social media, an embarrassed Google quickly disabled image generation on Gemini. It also issued a blog post, where company senior vice president Prabhakar Raghavan apologised, saying that "it's clear this feature missed the mark", and adding that "if you prompt Gemini for images of a specific

“It refused to weigh in when asked whether Hitler or Elon Musk tweeting memes had a more negative impact on society”

The power of Gemini

Unfortunately for Google, the controversy that derailed Gemini's launch meant that one important fact about Gemini was not widely appreciated: that the new Gemini 1.5 model is actually rather powerful indeed.

According to the company, Gemini's enterprise offering can accept up to a million tokens as context—that's the input data that can be processed by the system, such as individual words, letters or other pieces of data. This means that users can feed Gemini 700,000 words, 30,000 lines of code, or even 11 hours of audio or an hour of video, and ask the AI to interrogate it. That's around five times as many tokens as OpenAI's GPT-4 Turbo model.

The company claims it is more efficient than GPT-4, too, meaning that it can compute

responses much more quickly, thanks to a "Mixture-of-Experts" architecture that splits different types of computational tasks into different sub-models to hasten the speed of results.

That means Gemini should conceivably be capable of even more advanced computation than rivals such as ChatGPT. And although it's early days, we're starting to see some signs of what it can do.

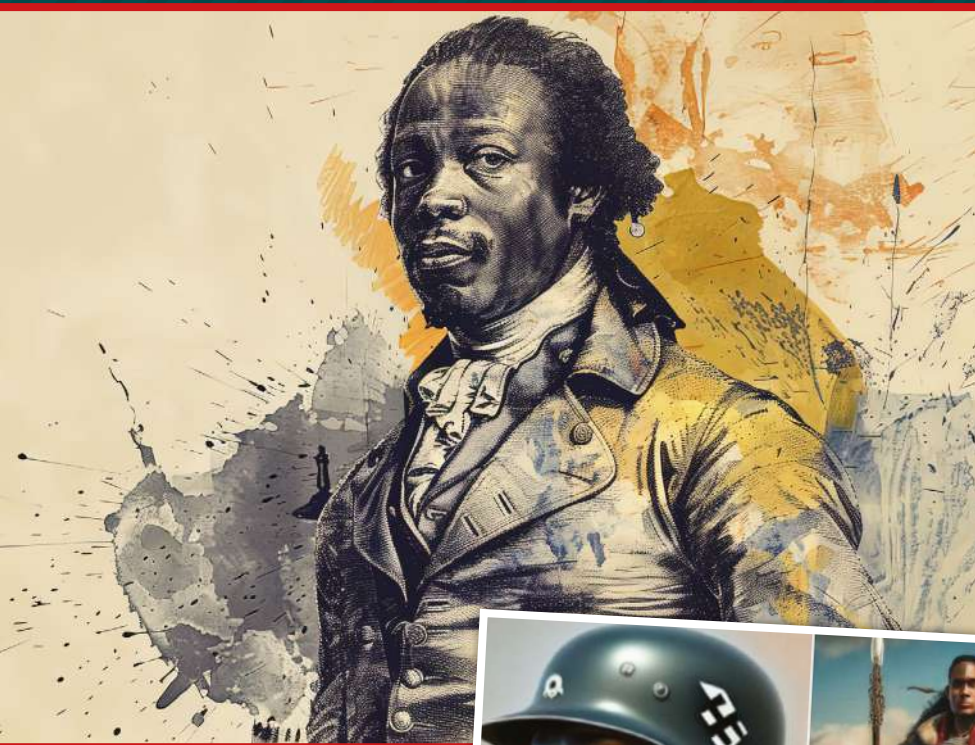
For example, the legendary web technologist Simon Willison wrote a blog describing how he used Gemini to parse the contents of a video clip. To test the system, he uploaded a clip a mere seven seconds long, with the camera quickly and erratically panning across his bookshelf. He then asked Gemini to look at the video and generate a

JSON file (essentially a form of structured data like storing a dataset) of all the books on the shelf.

"Honestly, I'm pretty astonished by this," Willison wrote. "It didn't get all of them, but it did about as good a job as I could have done given the same video."

However, as another example of Gemini's rather restrictive guardrails, his second attempt with a video scanning cookbooks didn't work as successfully, with Gemini outright refusing to parse his request. "It looks like the safety filter may have taken offence to the word 'cocktail!'" wrote Willison.

Nonetheless, he remains impressed. "This really does feel like another one of those glimpses of a future that's suddenly far closer than I expected it to be."



LEFT A mock-up (created in Midjourney) of the type of image that Google Gemini struggled to make historically accurate

type of person – such as ‘a black teacher in a classroom,’ or ‘a white veterinarian with a dog’ – or people in particular cultural or historical contexts, you should absolutely get a response that accurately reflects what you ask for”.

■ Human error?

Gemini’s painful failings led many to question the efficacy of Google’s AI model, but it seems that the people programming the AI are more likely culprits. People who acted with the best possible intentions, at that.

“Models are only as good as the data they’ve trained [on],” said Michal Szymczak, head of AI strategy at software development firm Zartis. “Obviously for something like Gemini that’s not a major problem because they scrape most of the internet, which wasn’t really possible a few years ago.”

But on its own, all of this scraping doesn’t add up to a reliable model. “If you try hard enough, you can find lots of texts ‘proving’ that the Earth is flat on the internet,” said Szymczak. “Imagine adding that to your model.”

So the developers of LLMs are inevitably forced to make decisions about how to train and tune their models to deliver more reliable results. Amazingly, this isn’t done by writing lines of code or by filtering a database, but by the developers essentially asking the model nicely in plain English by writing a prompt – exactly how end users interact with it.

“There’s all kinds of bits and pieces like that you can do to influence the personality of a model,” said Luke Budka, AI director at communications firm Definition, which helps companies design and build the right voices for their AI assistants, such as customer service bots.

He describes “prompt engineering” – the act of writing prompts to sculpt responses – as a skill in itself. The goal is to have the AI act and speak in a specific way. “You can give it a specific role and you can give it a specific tone of voice,” he said. “You can tell it what audience it’s going to be interacting with and therefore how it should act. And you can give it examples of previous interactions for it to learn from.”



ABOVE Images allegedly created by Google Gemini

Images are reasonably diverse and avoid stereotypes, while remaining broadly historically accurate.

So why did Gemini seem to go ahistorical? “I think it was just like overbearing training,” said Budka. “They obviously had an objective and that was to ensure that the results were diverse, and they just went a little bit too far.”

■ Imposing values

This leads to a final, broader question: how did Google end up releasing a product that was so quickly met with ridicule? “The biggest obstacle... above and beyond business model, is clearly culture,” wrote veteran technology analyst Ben Thompson in *Stratechery*, who speculates that the reason Gemini behaved as it did is because after two decades as top dog, Google became complacent, and believed it could instil and not just reflect the values of its users.

In any case, Gemini now stands as a striking lesson about how difficult it is to tune an AI system to account for biases and ambiguity – something that tech firms are going to have to take seriously if we continue to deploy AI to make decisions in our lives. And that makes Budka think that the AI future won’t only require expert coders and data scientists, but expertise in another crucial area, too. Professionals such as “linguists and language experts and sociologists and behavioural psychologists, people who understand how people work and how they interact with language and what language can inspire them to do, are going to be more in demand than ever”.

“ Gemini now stands as a striking lesson about how difficult it is to tune an AI system to account for biases and ambiguity ”



Best of MWC Barcelona 2024

We headed to the Catalan capital for the annual release-fest of all things mobile, from phones to tablets to AI PCs



Lenovo Project Crystal

PRICE Not confirmed

AVAILABILITY Proof-of-concept only

I'm not sure anyone ever asked "What if I could look through my laptop's display?", but regardless, Lenovo has created a laptop with a transparent display. And it's really rather cool.

Dubbed Project Crystal, this concept laptop uses a transparent micro-LED panel fitted between two panes of Gorilla Glass to equip the machine with a screen that you can see through as if it were just a rectangle of pure glass. And despite this, the icons and windows on the display were still crisp and clear.

It's been designed with the idea of creating "a more collaborative laptop experience", enabling users to see other people when they're also looking at the screen, instead of being hidden behind it. There are also AI-powered AR options thanks to an outward-facing webcam on the laptop's rear.

I don't expect to see a bunch of Lenovo laptops with transparent screens in the near future, but this is an intriguing glimpse of where computer screens could go next. And how they might evolve into something that almost blends into the environment rather than sticking out. **LANCE ULANOFF**

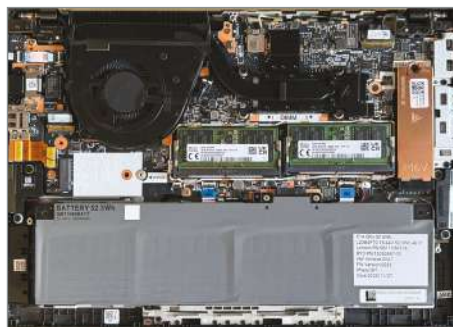


Lenovo ThinkPad T14 series

PRICE T14 Gen 5, from €1,349; T14s Gen 5, from €1,449; T16 Gen 3, from €1,369 from lenovo.com/uk (all prices exc VAT)

AVAILABILITY April to June 2024

Never mind transparent laptop screens: let's get practical and talk about Lenovo's biggest innovation of MWC 2024, namely a truly repairable ThinkPad. Yes, it's true that easy-to-replace batteries were commonplace 20 years ago, but not in such sleek laptops as the T14, T14s and T16. All three machines have been made far more repairable thanks to an ongoing partnership with iFixit, taking the T14 from a 7.3/10 rating two years ago to 9.3/10 for this G5 version.



You can also easily replace the ports (other than Thunderbolt), speakers, the touchpad, the screen, the keyboard and the SSD. Memory is soldered on the slimline T14s, but replaceable on the other two models, and Lenovo says it's working on making the cooling system replaceable in the future. **TIM DANTON**

Honor MagicBook Pro 16 (2024)

PRICE To be confirmed

AVAILABILITY To be confirmed

This is the most compelling AI PC I've yet seen. That's because it hits the holy trinity: an NPU



courtesy of Intel's Core Ultra 7 chip, Nvidia RTX 4060 graphics (which will provide a huge help in many generative AI tasks) and some genuine efforts by Honor and Microsoft to add software that will take advantage. Indeed, Mark Linton, a VP at Microsoft, said this device would showcase "the potential of on-device AI and cloud-based AI working together", hinting that it might be powered by voice. We shall see.

Honor will be producing a purple model along with the white version I played with at MWC, and with a matte white finish it looked striking. It's pretty slim, too, and weighs a shade under 1.9kg – not bad considering all the hardware inside, including a wide gamut 16in IPS panel with a 165Hz refresh rate and 3,072 x 1,920 resolution. The webcam is great, too, while Honor reckons the 75Wh battery can power it for 12 hours of typical use. I don't have a release date or price yet, but knowing Honor the latter will be extremely competitive. **TIM DANTON**

Energizer Hard Case P28K

PRICE €250 • **AVAILABILITY** October 2024

Barry Collins got very excited when he heard about this Android phone with a 28,000mAh battery. "Find it, Tim," he commanded. So I did, and it turned out to be more of a battery pack with a phone grafted into it – indeed, Avenir



Telecom (the French company that licenses the Energizer brand) essentially used one of their existing battery packs as the base.

It's huge. Not merely because of the size of the battery, but also the metal housing to protect it from bumps and bashes. It even has an IP69 rating. While the rest of the specs are mid-range (MediaTek Helio G99 CPU, 6.8in IPS FHD+ display, 8GB RAM, 256GB storage), the promise of week-long battery life makes this a tempting choice for off-grid workers and adventurers. And Barry. **TIM DANTON**



MoovBuddy for business

PRICE £150 per person per year from moovbuddy.com • **AVAILABILITY** Now

MWC isn't just about gadgets: there's a big emphasis on startups, too, and I grabbed a few minutes with the founder of MoovBuddy, Güner Bayram. This is already a popular app and health service, which complements data grabbed from your phone with those from earbuds (to check posture) and even physio consultancy.

"People experience back pain, neck pain and similar problems because of their working and daily routines," Bayram told me. "They need to go to clinics or visit a doctor [and] spend a lot of time and sometimes money solving this, but we give an alternative way with the digital instruments they have actually got." The idea is that "MoovBuddy creates a personalised, physical plan to restore their health".

With MoovBuddy for business, the company hopes to sell its service as a unique perk – which should also keep workers productive at their desks – for £150 per person per year. **TIM DANTON**

Humane AI Pin

PRICE \$699 plus \$24 monthly subscription from humane.com • **AVAILABILITY** Now (US only)

The Humane AI Pin wants to "turn the world into your operating system" via a personal assistant the size of a lapel pin. With a camera, microphone, GPS and cellular connection, the OpenAI-powered device drinks in information and requests such as "how much is \$50 dollars over here" and answers via a speaker, LEDs and a laser ink display that projects onto your palm. The camera records your gestures, interprets them and cycles through the options on the laser display.

I was sceptical, until I saw it work in person at MWC when that scepticism turned to delight. I was particularly impressed by the careful considerations



for practical problems: the magnetic backing that allows it to clip onto your clothing is also a battery pack, LEDs on the front of the display flash to indicate when the device is recording, and all data is end-to-end encrypted for security.

It's not yet perfect. The AI confused my shirt for a hoodie, and it's very expensive, along with being US-only right now. However, like the Apple Vision Pro, that price is likely to come down with subsequent generations. It was the most unique, forward-thinking wearable at MWC this year.

DARREN ALLAN

Seaborough "sunlight" laptop

PRICE \$10 per laptop (estimate)

AVAILABILITY Prototype only

What if using a laptop could actually be good for you? That's what Dr Anne Berends, Seaborough's programme director life science, is aiming for with technology that can bathe you in sunlight as you work. Well, kind of. "The idea is centred around near infrared light," she told me at MWC. "We aim to bring these near infrared lights into the built environments so that people who spend their days indoors get healthier."



The demo stand included a laptop with near-infrared lights surrounding its webcam, and Dr Berends hopes that manufacturers will embrace the idea and integrate the technology into future laptops and screens. She estimates a cost of \$10 per laptop, which sounds like a cheap solution to a definite problem. **TIM DANTON**

Clicks for iPhone

PRICE From \$139 from clicks.tech

AVAILABILITY Now (limited availability)

I caught up with Adrian Li Mow Chings, co-founder and CEO of Clicks, at MWC – only to discover that he subscribes to *PC Pro* but that his brother steals his copy. This trivia aside, I asked about his thinking about this add-on keyboard for the iPhone. "Our mission was, how do we make iPhones and the iOS

experience even better? How do we allow people to access the full screen? How do we enable shortcuts, because there are some great shortcuts in iOS? How do we give people that tactile feel of buttons?"

I tried the end result, which instantly reminded me of BlackBerry keyboards – and it turns out that the team includes an ex-BlackBerry industrial designer. The initial batch of keyboards is now sold out, but you can reserve keyboards in BumbleBee yellow or London Sky grey for the iPhone 14/15 Pro (\$139) and 14/15 Pro Max (\$159). **TIM DANTON**



Motorola Adaptive Display concept

PRICE Not confirmed • **AVAILABILITY** Proof-of-concept only

For all the foldable and rollable concept smartphones we've seen over the years, few have been practical. That's what's so exciting about Motorola's adaptive display concept – it's a smartphone that can bend into almost anything you need it to be.

Though we got a tease of the backward-bending phone at Lenovo Tech World late last year, MWC gave us our first opportunity to go hands-on with the device. Featuring a

6.9in OLED display, the still-nameless Android phone can bend backwards from flat to a number of different configurations.

The most noteworthy of those configurations switches the device to a smartwatch that straps to your wrist with the help of a magnetic bracelet accessory. Yes, it's still clunky, but a product promising to merge two of my daily devices into one? You have my attention. **KATE KOZUCH**



The A-List



The best products on the market, as picked by our editors

PREMIUM LAPTOPS

Apple MacBook Pro 16in (2023)

M3 power from £1,699
from apple.com/uk

The M3 chips give the already brilliant MacBook Pro series a boost in games with no sacrifices elsewhere, so power users who are happy with Apple must grapple with the big decisions: which M3 chip, which size of screen, and how much RAM and storage?

REVIEW Issue 352, p46



BUSINESS LAPTOPS

Lenovo ThinkPad X1 Carbon Gen 11

Business class from £1,583 exc VAT
from lenovo.com

Fight past Lenovo's opaque pricing – another flash sale, really? – and you'll find a slim, powerful and long-lasting laptop for a competitive price. With a wide range of available configurations, all based on Intel's 13th generation Core chips, this is our top choice for all sizes of business.

REVIEW Issue 350, p85



ALTERNATIVES

NEW ENTRY

HP Spectre x360 14 (2024)

An Intel Core Ultra 7 processor means that this is a fast 2-in-1 as well as being beautifully designed, with a sumptuous screen and excellent battery life. **£1,899 from hp.com/uk**

REVIEW Issue 355, p62

Apple Mac Book Air 13in (M3)

Both the 13in and 15in MacBook Airs impress for speed, styling and battery life, but the 1.2kg 13in Air wins out of the two for its sheer portability. **From £1,299 from apple.com/uk**

REVIEW Issue 356, p54

Samsung Galaxy Book4 Pro 16in

This super-sleek laptop packs amazing battery life thanks in part to Intel's Core Ultra 7 processor, while the 16in OLED panel is a joy to behold. **£1,699 from samsung.com/uk**

REVIEW Issue 355, p64

GAMING LAPTOPS

NEW ENTRY

Asus ROG Zephyrus G14 (2024)

Ultraportable gaming from £2,400
from rog.asus.com

Asus' ROG Zephyrus range of gaming laptops has always placed an emphasis on portability, but this sleek 1.5kg laptop takes that to a new level. It maxes out at an RTX 4070, but that's enough to deliver triple-figure frame rates in AAA games – and the 120Hz 14in OLED screen just adds to the speed.

REVIEW Issue 356, p60



ALTERNATIVES

Lenovo Legion 9i Gen 8 (16in Intel)

The liquid-cooling system may be only for bragging rights, but this slim laptop delivers the goods with a superb 16in mini-LED screen. **RTX 4090, £4,180 inc VAT from lenovo.com**

REVIEW Issue 353, p58

Lenovo Legion 5i Pro (16in)

A great-value gaming laptop that extracts the most from its powerful components. We love the keyboard, too. **Part code 82RF002LUK, £2,000 from lenovo.com/gb**

REVIEW Issue 337, p61

Razer Blade 18 (2023)

A great advert for 18in gaming laptops, the Blade 18 partners a Core i9-13950HX with RTX 40-series graphics. **From £2,900 from razer.com/gb-en**

REVIEW Issue 343, p52

EVERYDAY LAPTOPS

Honor MagicBook 16 X (2023)

Full metal jacket for £700
from hihonor.com

A high-quality all-metal chassis marks the MagicBook 16 X 2023 out from the budget laptop crowd, and it's packed with good-quality (albeit not top-quality) components, from a 12th gen Core i5 chip to a 1,920 x 1,200 16in IPS panel.

REVIEW Issue 348, p59



Asus Vivobook S 15 OLED

The Core i5 version of this 1.7kg laptop offers amazing quality for under a grand, including a high-quality 15.6in OLED display. **From £949 from pcpro.link/347asus2**

REVIEW Issue 347, p85

Microsoft Surface Laptop Go2

The Laptop Go 2 won our recent group test of affordable laptops thanks to its high-quality 12.5in screen, 1.1kg weight and sleek design. **£555 from microsoft.co.uk**

REVIEW Issue 347, p89

MSI Prestige 15

Not the most cultured laptop, but great value considering the connectivity, 15in screen, fast specs and a GeForce RTX 3050 GPU (part code A12UC-034UK). **£849 from laptopoutlet.co.uk**

REVIEW Issue 347, p93

CHROMEBOOKS

NEW ENTRY

NEW ENTRY

NEW ENTRY

Acer Chromebook Spin 714

Flipping great for £799

from [currys.co.uk](https://www.currys.co.uk)

Simply the best Chromebook around. Others may beat the 12th gen Intel Core i5 we tested for performance, but for features, design and bang for buck you won't find any laptop that can match this convertible for £799.

REVIEW Issue 356, p83



Acer Chromebook Plus 515

This Chromebook Plus laptop is all about value. With strong speeds thanks to Intel's Core i5-1235U processor, and a good-quality 15.6in panel with a 1,920 x 1,080 resolution, Asus' Chromebook Plus 515 is ideal for families, students and business users, providing mobility isn't your main priority as it isn't particularly light at 1.7kg. **£429 from [currys.co.uk](https://www.currys.co.uk)**

REVIEW Issue 356, p82

Lenovo IdeaPad 5i Gaming Chromebook Plus

The 120Hz 15.6in display is the star of this Chromebook, as it should be with 2,560 x 1,600 pixels to play with. You're getting a lot of laptop for the price, too, including a 512GB SSD, Core i5-1235U processor and 8GB of RAM. Just note the 1.9kg weight.

£659 from [very.co.uk](https://www.very.co.uk)

REVIEW Issue 356, p88

EVERYDAY PCs

Apple Mac mini (2023)

M2 masterpiece from £649

from [apple.com/uk](https://www.apple.com/uk)

The outside remains the same, but this simple yet effective update to the Mac mini introduces the M2 and M2 Pro processors with predictable effect. The entry-level price quickly rises once you start upgrading – moving from 8GB to 16GB costs £200, as does doubling the base storage from 256GB to 512GB – but there's enough power here to last you for years.

REVIEW Issue 343, p60



Intel NUC Pro 13

If you don't need discrete graphics then Intel's mini PCs are a fantastic choice, being easy to upgrade, low on energy consumption and more than powerful enough to cope with Windows applications – despite being little larger than a coffee coaster.

Barebones, from £350; full PCs, from £600, from [scan.co.uk](https://www.scan.co.uk)

REVIEW Issue 345, p48

PCSpecialist Fusion Elite P

A promising debut for AMD's Ryzen 8600G processor, this quiet-running, power-efficient system packs in lots of performance considering it costs so little. And a slot sits empty for a future graphics card upgrade should the built-in graphics prove insufficient for your gaming needs. **£649 from [pcspecialist.co.uk/reviews](https://www.pcspecialist.co.uk/reviews)**

REVIEW Issue 355, p54

ENTHUSIAST PCs

NEW ENTRY

Cyberpower Ultra R77 RTX Gaming PC

RTX Super 4080 power for £2,275

from [tinyurl.com/356cyber](https://www.tinyurl.com/356cyber)

The striking case catches the eye, but it's the potency of AMD's Ryzen 7 7800X3D and Nvidia's RTX 4080 Super graphics that leave the lasting effect.

REVIEW Issue 356, p62



HP Omen 45L (2023)

We tested the top-end 45L with a Core i9-13900K, GeForce RTX 4090 graphics and 64GB of RAM, and it doesn't come cheap. Switch to the Core i7/RTX 4070 Ti version, however, and the price almost halves without losing any of the superb design and build quality. **£4,800 from [hp.co.uk](https://www.hp.co.uk)**

REVIEW Issue 347, p50

Alienware Aurora R16

An understated yet stylish gaming PC that runs quietly even when pushed. This rig has power where it counts, mixing Intel's latest CPUs with Nvidia's RTX GPUs. Choose an RTX 4070 or higher to benefit from the glass side and liquid cooling, which lifts it above rivals. **From £1,349 from [dell.co.uk](https://www.dell.co.uk)**

REVIEW Issue 349, p54

ALL-IN-ONE PCs

HP Envy 34 All-in-One

£2,099 widescreen wonder

from [hp.com](https://www.hp.com)

Built around a high-quality 34in widescreen – which is perfect for viewing two windows side by side thanks to its 21:9 aspect ratio – this also comes with Nvidia RTX 3060 graphics. We're big fans of the magnetic 16-megapixel camera, too.

REVIEW Issue 335, p46



Dell Inspiron 24 All-in-One

Despite being built to hit a price point, the Inspiron 24 All-in-One manages to look classy, include a good-quality, 1,920 x 1,080 24in panel and have enough power to breeze through a typical day's tasks. It even packs mod cons such as a 720p webcam. Superb value for money.

From £599 from [dell.co.uk](https://www.dell.co.uk)

REVIEW Issue 350, p47

Apple iMac 24in (M3)

The iconic design remains the same, but the plain M3 chip inside the revamped iMac 24in is a revelation compared to the previous M1 version. The downside is that the base configuration includes a stingy 8GB of memory and a 256GB SSD.

From £1,399 from [apple.com/uk](https://www.apple.com/uk)

REVIEW Issue 352, p52

CREATIVE WORKSTATIONS

Scan 3XS GWP TR Ada

Record breaker for £14,167 exc VAT

from [scan.co.uk](https://www.scan.co.uk)

A 64-core Ryzen Threadripper 7980X blows everything that went before out of the water with multithreaded tasks, while Nvidia's RTX 6000 Ada graphics dominates for viewport acceleration and GPU rendering. Even storage throughput is unparalleled. With a striking chassis and brilliant build quality, you'll want for nothing.

REVIEW Issue 353, p52



Armari Magnetar MC16R7

A strikingly fast workstation for the money, with Armari's customised liquid cooling extracting the most from an AMD Ryzen 9 7950X. With 64GB of DDR5 RAM and AMD's Radeon Pro W7800 in support, this is a fantastic value machine.

£3,758 exc VAT from [armari.com](https://www.armari.com)

REVIEW Issue 348, p84

PCSpecialist Onyx Pro

Even in a creative workstation, it makes a lot of sense to include Nvidia's consumer graphics due to its core-per-buck. Here, an Nvidia RTX 4090 partners with a Core i9-13900K and an incredible 192GB of RAM to tremendous effect. **£3,750 exc VAT from [pcspecialist.co.uk/reviews](https://www.pcspecialist.co.uk/reviews)**

REVIEW Issue 348, p86



TABLETS

Apple iPad Pro 12.9in

Simply the best, from £1,249

from apple.com/uk

The best tablet out there thanks to Apple's powerful M2 chip, even if the upgrade prices sting in their usual fashion. In return you'll get a workhorse during the day (especially with the optional Magic Keyboard) and a brilliant entertainer at night.

REVIEW Issue 352, p84



Samsung Galaxy Tab S9 Ultra

The best of the big-screen Android tablets, with the bonus of Samsung's DeX environment if you want to use it as a desktop replacement, while One UI lets you manage multiple windows and multitask between them. The 14.6in AMOLED screen is superb, too.

From £1,199 from samsung.com

REVIEW Issue 352, p87

OnePlus Pad

The OnePlus fully justified its place in our luxury tablet Labs thanks to its outstanding build quality, slick performance and stunning 17-hour battery life. It's the best Android option outside of Samsung's Galaxy Tabs – and it won't do nearly so much damage to your wallet.

£449 from oneplus.com

REVIEW Issue 352, p86

EVERYDAY PHONES

Motorola Moto G54 5G

Great looker for £180

from johnlewis.com

The 6.5in 120Hz IPS display is the G54's standout feature, but it improves on the previous generation in numerous ways while being even cheaper. It's faster, looks better, takes great photos and battery life is strong. You won't find better for less than £200.

REVIEW Issue 355, p77



Google Pixel 7a

A phone that begs the question: why spend £150 more for the Pixel 7? With few compromises on the Pixel 7 – it uses the same processor and cameras and the only notable change is a smaller screen – this is the new mainstream pick for Google phone fans.

128GB, £449 from store.google.com

REVIEW Issue 346, p68

Motorola Edge 30 Neo

This stylish and compact smartphone – reflected by a small-ish 4,200mAh battery – includes a gorgeous 6.3in OLED screen, nippy Snapdragon processor and a decent pair of cameras for a great price.

£300 from motorola.co.uk

REVIEW Issue 348, p73

PREMIUM PHONES

Samsung Galaxy S24 Ultra

AI cleverness from £1,249

from samsung.com/uk

The undeniably high price gets you a bunch of AI tools that will genuinely save you time (and money). While we miss the 10x optical zoom of the S23 Ultra, the 5x zoom camera and supporting cast capture brilliant images, while the S Pen is always on hand to scrawl notes and pictures.

REVIEW Issue 354, p58



Google Pixel 8

It's not a huge step up from the Pixel 7, but the added AI features are genuinely useful and it benefits from a handful of upgrades, too – including a 120Hz screen and the new Tensor G3 processor. If you don't mind the lack of optical zoom, it's a great buy for the price.

128GB, £699 from store.google.com

REVIEW Issue 351, p72

Samsung Galaxy Z Flip5

While the Galaxy Z Fold5 has its undoubted attractions, the Flip5 pips it onto this A List slot thanks to it being £700 cheaper and through the usefulness of the expanded front display. It's also IP68 rated and packs a stellar chip, beating rival flip phones.

From **£1,049 from** samsung.com/uk

REVIEW Issue 349, p70

EVERYDAY MONITORS

Lenovo ThinkVision P27u-20

4K Thunderbolt, £550

from lenovo.com

We reviewed this when it cost £470, but even at £550 it's a superb buy. It's a top-quality 27in panel with a 4K resolution, and it packs superb connectivity, including Thunderbolt 4.

REVIEW Issue 344, p89



AOC Q27P3CW

If you can't afford the ThinkVision P27u-20 then this 27in USB-C docking monitor, complete with solid image quality and a 1440p resolution, offers unmatched value at a shade over £300. It even includes a webcam that supports Windows Hello.

£310 from box.co.uk

REVIEW Issue 344, p83

Iiyama ProLite XCB3494WQSN

Curved 34in monitors proved a popular choice in our Labs, and although it had tough competition from the HP E34m G4 this Iiyama steals a spot on our A List due to Iiyama's twin focus on value and quality panels. There's even gaming potential.

£400 from scan.co.uk

REVIEW Issue 344, p88

PROFESSIONAL MONITORS

Eizo ColorEdge CG319X

Creative masterclass, £3,960

from wexphotovideo.com

As the price indicates, this monitor is for heavyweight creatives who demand the best in every discipline: HDR video editing, print layouts, professional photography and more besides. With superb coverage and accuracy across all spaces, plus a built-in calibrator, it justifies the investment.

REVIEW Issue 327, p81



BenQ PD2725U

By no means a cheap 4K 27in monitor – unless you compare it to the Eizos – but it marries all-round quality with ease of use thanks to a puck that allows you to quickly move between settings. You can even daisy chain a second Thunderbolt 3 monitor for a monster setup.

£859 from photospecialist.co.uk

REVIEW Issue 327, p80

Eizo ColorEdge CG279X

Designers who need to work across different disciplines will love how easy it is to switch between the Adobe RGB, DCI-P3 and sRGB colour spaces using the Eizo's fantastic OSD. It's certainly not cheap for a 27in 1440p monitor, but it's packed with quality.

£1,726 from wexphotovideo.com

REVIEW Issue 327, p84

WEBCAMS

NEW ENTRY

Logitech MX Brio 705 for Business

Consistent brilliance for £219

from [logitech.com](https://www.logitech.com)

Consistent image quality in all lighting conditions coupled with top build quality and nifty features – such as a presenting mode for items on your desk – make this a fantastic all-round choice.

REVIEW Issue 356, p68



Aukey PC-W3 1080p Webcam

If the thought of spending £142 on a webcam has you spluttering into your microphone then you should consider this far cheaper but high-quality alternative. Its colours are low-key in comparison to the best, but it still produces a sharp and detailed image. **£13 from [ebay.co.uk](https://www.ebay.co.uk)**

REVIEW Issue 321, p72

Obsbot Tiny 2

This portable 4K webcam delivers for quality, design and sharpness, and it comes with a shedload of advanced features, including dynamic zoom and subject tracking. The only real downside is that it has a price that reflects its premium ambitions.

£329 from [amazon.co.uk](https://www.amazon.co.uk)

REVIEW Issue 352, p75

HOME OFFICE PRINTERS

Epson EcoTank ET-2830

Ink tank all-in-one for £250

from [epson.co.uk](https://www.epson.co.uk)

Don't expect flashy features, but do expect fast print speeds, high-quality prints, scans and copies, plus phenomenally low running costs – even after you've exhausted the 6,000 pages' worth of bottled ink that comes with it.

REVIEW Issue 353, p85



Canon Pixma TS8750

A fantastic choice for creative users that's equally at home printing photos as it is scanning artwork. Despite its high running costs, due to its reliance on cartridges, this is a superb all-in-one. **£159 from [printerbase.co.uk](https://www.printerbase.co.uk)**

REVIEW Issue 353, p86

HP OfficeJet Pro 9012e

So long as your print volumes aren't huge – the running costs mount up – this is a superb all-in-one for home office usage. It's fast, robust, prints double-sided and produces strong all-round results.

£208 from [printerland.com](https://www.printerland.com)

REVIEW Issue 353, p87

WORKGROUP PRINTERS

Canon Maxify GX6550

Ink tank all-in-one for £392 exc VAT

from [canon.co.uk](https://www.canon.co.uk)

Designed to fit in tight spaces, this all-in-one includes a highly effective ADF and backs it up with high-quality prints at 24ipm in our tests. Running costs are superb, too.

REVIEW Issue 350, p58



Brother HL-L9430CDN

This laser printer (not an all-in-one, so there's no scanning or copying functionality) is a great choice for a busy office, producing sharp black text and making a good job of colour graphics as well. All while doing so quickly with a competitive price per page. **£415 exc VAT from [printerland.co.uk](https://www.printerland.co.uk)**

REVIEW Issue 353, p84

Xerox B315DN

A fine alternative to the Brother and Canon, this mono laser multifunction printer produces superb results at great speed – 27.5 pages per minute in our 50-page test, which includes the spool time. It's similarly quick for scans, with a dual-CIS ADF to speed up double-sided copies. **£238 exc VAT from [printerbase.co.uk](https://www.printerbase.co.uk)**

REVIEW Issue 341, p87

WIRELESS ROUTERS

Netgear Nighthawk RAXE300

Fast Wi-Fi 6E router, £350

from [amazon.co.uk](https://www.amazon.co.uk)

The RAXE500 (see right) is faster than the RAXE300, but in practice we doubt you would notice – this tri-band router still delivered speeds between 50MB/sec and 150MB/sec in our tests. And it's packed with features, too. At £150 cheaper than its bigger brother, we think it hits the Wi-Fi 6E sweet spot.

REVIEW Issue 341, p68



Netgear Nighthawk RS700S

Make no mistake – you won't get stunning speeds out of this Wi-Fi 7 router today. But if you must buy a router now and want future-proofing, this is a solid choice. But honestly, we would recommend that you wait.

£800 from [netgear.com](https://www.netgear.com)

REVIEW Issue 353, p76

Asus RT-AX59U

You can buy cheaper Wi-Fi 6 routers – such as the D-Link Eagle Pro AI R15 for £55 – but Asus' well-priced offering delivers strong performance along with lots of control and exceptional VPN support. **£125 from [uk.store.asus.com](https://www.uk.store.asus.com)**

REVIEW Issue 350, p57

MESH WI-FI

TP-Link Deco XE200

Clever Wi-Fi 6E for £600

from [amazon.co.uk](https://www.amazon.co.uk)

There are cheaper Wi-Fi 6E meshes, but the XE200 wins for its superb download speeds, excellent coverage and the fact that older clients reap benefits of 6E, not just new ones. And a two-pack (code BOBKTDPCW8) should be enough for most premises.

REVIEW Issue 349, p65



Mercusys Halo H80X

A new subsidiary of TP-Link, Mercusys offers its parent brand's XE75 router some excellent value-for-money competition. Not as fast due to Wi-Fi 6 rather than Wi-Fi 6E, but it has all the bandwidth you need for everyday use and should deliver it stably throughout your house. There are plenty of features too. **2-pack, £161 from [ebuyer.com](https://www.ebuyer.com)**

REVIEW Issue 341, p71

Linksys Velop Pro 6E

Ironically, this Wi-Fi 6E router will get the most out of your non-Wi-Fi 6 devices thanks to its use of the 6GHz network for station-to-station traffic. And you only need two units for rock solid performance across a three-bedroom house. **2-pack, £380 from [amazon.co.uk](https://www.amazon.co.uk)**

REVIEW Issue 350, p54



BUSINESS WI-FI

Zyxel WAX640S-6E Wi-Fi 6E AP, £369 exc VAT

from broadbandbuyer.com

A nicely priced tri-band wireless access point ideally suited to businesses that want to provide the full range of wireless services. It's easy to deploy, wireless performance is good and Zyxel provides top-quality cloud management services.

REVIEW Issue 353, p100



Asus ExpertWiFi EBM68

Small businesses will find much to like with this simple-to-manage Wi-Fi 6 access point. AiMesh makes it incredibly easy to expand wireless coverage, performance is reasonable and it includes an impressive range of network security features. **2-pack, £540 exc VAT from amazon.co.uk**

REVIEW Issue 353, p98

Netgear WAX625

A great choice for SMBs seeking an easy wireless performance boost with minimum investment. This is an affordable Wi-Fi 6 AP with good speeds while Netgear's Insight provides smart cloud management services. **£224 exc VAT from broadbandbuyer.com**

REVIEW Issue 353, p99

NAS SERVERS

Synology DiskStation DS1823xs+

10GbE NAS, £1,413 exc VAT

from broadbandbuyer.com

This powerful eight-bay NAS is a great choice for SMBs that want plenty of capacity, features and performance at a reasonable price. The new DSM 7.2 software has security high on its agenda, and the icing on the cake is Synology's generous five-year warranty.

REVIEW Issue 346, p101



Qnap TS-h987XU-RP

The TS-h987XU-RP is a ready-made hybrid storage solution for SMBs. This rack-friendly package offers a great specification for the price, and Qnap's QuTS hero software scores highly for its wealth of data-protection features and business apps. **Diskless, £3,292 exc VAT from broadbandbuyer.com**

REVIEW Issue 344, p96

Synology DiskStation DS1522+

Small businesses that want a high-capacity desktop NAS at a good price will find Synology's DS1522+ a great choice. Performance over 10GbE is impeccable and the DSM software offers a fantastic range of storage features. **5-bay NAS, diskless £586 exc VAT from broadbandbuyer.com**

REVIEW Issue 344, p98

VIDEOCONFERENCING

Poly Studio X52 with TC10 Perfect middle man, £3,161 exc VAT

from meetingstore.co.uk

Ideal for businesses that want a professional videoconferencing solution for medium-sized meeting rooms. Video quality is excellent, speaker tracking fast, and the big choice of built-in VC apps makes it incredibly versatile.

REVIEW Issue 353, p102



Owl Labs Owl Bar

As a standalone videoconferencing room solution the Owl Bar has plenty to offer, with good video quality and super-smooth speaker tracking. It really comes into its own when paired with an Owl 3, though, as this unleashes a completely new dimension to your meetings. **£1,999 exc VAT from owllabs.co.uk**

REVIEW Issue 352, p99

Jabra PanaCast 50

This sleek cylinder delivers great video and audio quality, fast speaker tracking and a wealth of advanced features. Jabra's Xpress web portal offers smart remote management services, and the super-wide view helps make the PanaCast 50 ideal for all-inclusive meetings. **£867 exc VAT from uk.insight.com**

REVIEW Issue 354, p100

SCANNERS

Xerox D70n Scanner

Fast and furious, £765 exc VAT

from ballicom.co.uk

The D70n delivers a mighty scan speed together with a wealth of scan management tools and apps. Businesses that want a high-volume networked desktop scanner at an affordable price should put the Xerox at the top of their list.

REVIEW Issue 346, p99



Brother ADS-4700W

A fine choice for small businesses, with an impressive range of scanning features at a price that can't be faulted. Output quality is top notch and the versatile LCD touchscreen menus provide great walk-up scan services. **£355 exc VAT from printerbase.co.uk**

REVIEW Issue 346, p96

Epson WorkForce ES-C380W

An affordable choice for offices short on space. It delivers on its 30ppm speed promises, Epson's ScanSmart software offers plenty of management features, and its standalone mode makes it very accommodating. **£280 exc VAT from ballicom.co.uk**

REVIEW Issue 351, p101

SERVERS

Dell EMC PowerEdge T350

Xeon E-2300 power, from £1,399 exc VAT

from dell.co.uk

Perfect for SMBs and branch offices looking for an affordable and powerful single-socket tower server. Along with support for Xeon E-2300 CPUs and lots of memory, it has a high storage capacity, plenty of expansion space and is sturdily built.

REVIEW Issue 335, p98



Dell EMC PowerEdge R250

With prices starting at around £850 exc VAT for a Pentium Gold CPU, and the option of Xeon E-2300 series chips from £1,461 exc VAT, this is a slim, rack-mounted alternative to the more high-powered T350 that's ideal for SMBs. **From £845 exc VAT from dell.co.uk**

REVIEW Issue 332, p98

Broadberry CyberServe Xeon E-RS100-E10

This represents a powerful hardware package at a price that will please small businesses. We love its low-profile chassis and the fine selection of remote-management tools. It's a great alternative to the Dell EMC servers also listed here. **£983 exc VAT from broadberry.co.uk**

REVIEW Issue 318, p96

SECURITY SOFTWARE

Avast Ultimate

Buy from retail and this is a bargain, with a solid VPN, anti-tracking software and handy detection fees on top of excellent protection. **10 devices, 2yrs, £30 from store.pcpro.co.uk**
REVIEW Issue 355, p84



G Data Total Protection

G Data provides straightforward, effective and inexpensive protection against malware and other threats to your system, making it a favourite despite its quirks. **5 devices, \$82 from gdatasoftware.co.uk**
REVIEW Issue 355, p87

Avast One Essential

Avast One Essential has the same malware-detection engine as our top choice, but for free. It even includes 5GB of VPN services per month and a few system optimisation tools. **Free from avast.com**
REVIEW Issue 355, p89

VPNs

NordVPN

NordVPN won our VPN Labs for the second time running thanks to its consistent, fast speeds, great security features and excellent support for video streaming. **£80 for two years from nordvpn.com**
REVIEW Issue 349, p86



ProtonVPN

The best free VPN service available, with quick speeds and unlimited bandwidth. The paid-for service isn't cheap, but offers a bunch of useful extra features that might just tempt you into coughing up. **Free from protonvpn.com**
REVIEW Issue 349, p88

Surfshark

The fastest VPN we've tested, and it's generally a good performer in our region-shifted streaming tests, too. Cancellation is trickier than it should be, but it's a great-value choice for heavy VPN users. **£56 for two years from surfshark.com**
REVIEW Issue 349, p89

PASSWORD MANAGERS

NordPass

This hassle-free option is a great choice for both personal and business use, with a competitive price matched with all the features most people need. **£1.89 per month from nordpass.com**
REVIEW Issue 350, p70



Bitwarden

Free for individual use and open source, the only important thing Bitwarden lacks is phone support: it works with virtually every device and browser, and the paid option is well worth £10 per year. **Free from bitwarden.com**
REVIEW Issue 350, p71

Keeper

A great choice for businesses thanks to its focus on security and a zero-knowledge policy, and if you need more options then Keeper has them. **Business edition, from £2 per user per month from keepersecurity.com**
REVIEW Issue 350, p72

ENDPOINT PROTECTION

Sophos Intercept X Advanced

Delivers a huge range of endpoint protection measures for the price. It's simple to deploy, device and user policies add flexibility, and seamless integration with the Sophos Central cloud portal makes management simple. **500-999 users, 1 year, £36.50 each exc VAT from enterpriseav.co.uk**
REVIEW Issue 351, p98



CLOUD STORAGE

ShareFile Premium

Cloud file-sharing features are on a par with many other solutions, but ShareFile Premium stands out for its generous 100GB file size support. Admin features and access security are extensive, and the new pricing structure makes it even more affordable. **£19.60 exc VAT per user per month from sharefile.com**
REVIEW Issue 355, p100



VOIP SERVICES

3CX

SMEs worried about the cost and complexity of hosting an IP PBX will love 3CX's free offering. It's easy to use and provides all the call-handling services you need. **Free for 1-10 users from 3cx.com**
REVIEW Issue 345, p96



WithSecure Elements EPP and EDR

High levels of automation make WithSecure a great choice for SMBs that want endpoint protection on a plate. It's easily managed from the cloud, too. **100-499 devices, £37 each per year exc VAT from withsecure.com**
REVIEW Issue 351, p99

Tresorit Business Plus

Tresorit's strict zero-knowledge encryption policy, excellent value and ease of use make it a great choice for security-conscious SMBs. **£12.83 exc VAT per user per month from tresorit.com**
REVIEW Issue 355, p101

Gradwell Wave

Ideal for SMEs that want the smoothest possible path to VoIP, this cloud-hosted service is easy to manage and packed with features. **Wave 100, from £7.50 exc VAT per user per month from gradwell.com**
REVIEW Issue 345, p98

NETWORK MONITORING

Progress WhatsUp Gold 2023.1

Simple to deploy and offers an impressive range of network-monitoring tools. The choice of licensing plans makes it an affordable option for SMBs, and support teams will love its smart dashboard and NOC views. **Enterprise, 50 devices, £1,192 exc VAT per year from whatsupgold.com**
REVIEW Issue 354, p99



REMOTE SUPPORT

IDrive RemotePC Team

IDrive's RemotePC Team will appeal to SMBs that want affordable cloud-hosted remote support for their offices and home workers. It's exceedingly simple to deploy, easy to manage and delivers tough access security measures. **First year, 50 computers, £172 exc VAT from remotepc.com**
REVIEW Issue 349, p98



UTM APPLIANCES

WatchGuard Firebox T45-CW

Businesses that hate internet downtime will love WatchGuard's Firebox T45-CW. It provides a wealth of top-class security services, can be easily cloud managed and delivers seamless 5G WAN failover. **Appliance with 3yr TSS, £4,015 exc VAT from broadbandbuyer.com**
REVIEW Issue 354, p103



Paessler PRTG Network Monitor 23.4

A highly versatile network-monitoring package that delivers a wealth of information, and its all-inclusive price makes it a great choice for SMBs. **1,000 sensors, 1yr maintenance, £2,649 exc VAT from paessler.com**
REVIEW Issue 354, p98

NetSupport Manager 14

Delivers a wealth of support tools, including secure access to home workers, and licensing plans are good value. **1-500 systems, perpetual licence, £10 each exc VAT from netsupportmanager.com**
REVIEW Issue 349, p100

Zyxel ZyWALL ATP500

This desktop appliance gives sophisticated protection against zero-day threats, is easily managed and very good value. **Appliance with 1yr Gold Security licence, £1,191 exc VAT from broadbandbuyer.com**
REVIEW Issue 348, p99



Oh, what a tangled cosmos YouTube weaves



Dick Pountain is editorial fellow of *PC Pro* and still just about capable of performing useful work on his surroundings. Email dick@dickpountain.co.uk

Ignore the clickbait on YouTube and you'll discover a rich well of videos that stimulate brain cells rather than generate dopamine hits

For all its faults, YouTube offers an unprecedented breadth and depth of content. There's all kinds of music, craft and sport on offer, even movies. Then there's the educational side. I watch a lot of mathematics videos, and while most lack the professional depth you find on Wikipedia, they often make up for that by exploiting visualisation in original and useful ways.

Then there's my favourite topic of all: science. Okay, many YouTube videos are of increasingly dubious, click-bait quality, and that applies to much of its science content, too. Unsurprisingly the science on YouTube is dominated by cosmology and particle physics, those perennial playgrounds for opinionated nerds who know that Einstein or Bohr were wrong (or right, or whatever). It's created a handful of stars like Sabine Hossenfelder and Derek Muller who talk sense and explain stuff well, but the nature of the medium means these get drowned out by the charlatans for most non-scientist viewers.

There are, however, "brands" that guarantee seriousness, and one of the best is the Royal Institution (RI). Head to its homepage and you can find Carlo Rovelli explaining white holes, learn about Humphry Davy and Michael Faraday, and discover how the Braggs created the field of crystallography.

I always watch the RI's Christmas lecture, because I like bangs, but this year YouTube offered me as follow-up a lecture by Prof Tim Palmer. His video about uncertainty and probability blew my mind, and pushed me to read his book *The Primacy of Doubt*.

“You’ve probably gathered by now that I’m one of those same opinionated nerds that I was deriding above”

Palmer works in mathematical physics and is an expert on chaos theory, turning his knowledge to practical use in weather forecasting; the huge extension of reliable forecasting in recent years is largely thanks to the method of “ensemble forecasts” he pioneered. Shocked by the failure of the Met Office to predict the 1987 hurricane, Palmer realised that the deterministic supercomputer models then in use were prone in rare cases to chaotically wrong prediction, which could be mitigated by feeding the model multiple starting conditions that differ by small additions of randomness. Instead of a single prediction, this produces a brush-like clump of predictions, the central trend of which is more likely to be right.

The theory behind his method involves the Lorenz equations, which describe the behaviour of chaotic dynamic systems. Solving these equations doesn't lead to single precise solutions, but to infinitely convoluted fractal graphs called attractors. Palmer's explanation of Lorenz's discovery in his RI lecture is superb, and he does it without writing any algebra or calculus on the blackboard. It's admirably accessible. That, however, is not what blew my mind: that happened when Palmer turned his method to cosmology.

Alongside his work in chaos theory, Palmer has a doctorate in general relativity, and he's tried to bring the two subjects together. Taking off from Einstein's theory that gravity is the effect of the curvature of space/time by matter, Palmer postulates that rather than being smoothly curved, space/time itself has fractal complexity, like the Lorenz attractors of chaotic systems.

I don't understand his “invariant set postulate” well enough to attempt

“If true, it would resolve several of the knottiest problems that currently occupy both cosmology and quantum physics”

further explanation here, but I know that, if true, it would resolve several of the knottiest problems that currently occupy both cosmology and quantum physics. Subatomic particles traversing a fractally convoluted space/time would explain quantum uncertainty without having to invent multiple universes. It could offer a theory of quantum gravity more plausible than any of the current candidates, and even do away with “non-locality” and the spooky action at a distance that so annoyed Albert Einstein.

You've probably gathered by now that I'm one of those same opinionated nerds that I was deriding above. I've ranted in this column before against people who employ their shaky grasp of quantum uncertainty to declare everything from “there's no such thing as reality” to multiple universes that provide mechanisms for magic and telepathy. As a humble chemist rather than a mathematical physicist, I'm not equipped to refute them in the way Palmer may be in the process of doing.

I believe the very real world we live in is ruled by thermodynamics, not quantum mechanics, whether that be the misbehaving battery in your electric car, the catastrophic increase in your utility bills, or those massive perturbations of atmospheric energy that we call our climate (and which may yet see the end of us if we don't start concentrating). Tim Palmer knows that better than almost anyone, and I have no hesitation in recommending that you watch his RI lecture at tinyurl.com/y56palmer.

dick@dickpountain.co.uk

Software design needs a reboot up the \$£%!



Nicole Kobie is PC Pro's Futures editor. One downside of using your phone for edits is accidental autocorrects, which is why some of her comments may come out sounding a bit bonkers. X@nikobie

The software on my laptop should be as easy to use as any modern-day appliance, so why can't Adobe and Microsoft get the basics right?

Is it just me, or is software getting worse? I want my laptop to behave like my toaster or kettle: appliances that just work as expected without any thought on my behalf. But the first time I tried to open the proof of my book, with its thousands of comments, typesetting marks and the rest, Acrobat simply refused to load. (Did I mention I have a book coming out in July? Yes, I have, and I will again, no apologies.)

I had only installed the full version of Adobe Acrobat on my laptop because I was testing its new AI assistant, which is a genuinely handy tool for digging data out of documents. But I wish Adobe had spent less time on whizzy AI features and more time on getting the basics right.

Every time I wanted to reply to a comment, Acrobat had a 50/50 chance of crashing or stalling for minutes. I tried everything I could think of to make it work, including switching to my husband's gaming laptop in case the issue was performance-related. After a full morning, I'd worked through only 20 pages, an untenable rate that would have put me on course

“I wish Adobe had spent less time on whizzy AI features and more time on getting the basics right”

to finish editing the proof in time for the paperback to come out.

Forum posts suggest this issue stretches back to at least 2019, so I ditched Acrobat for Nitro PDF. This opened the file just fine but ran the comments along the bottom of the page, and the mousing made for slow, wrist-killing work. I turned to the forums once more, but no luck: there's no way to change this layout. By this point, I'd spent more time reading about PDFs than working on my own.

In a fit of paranoia, being unsure that the Nitro PDF version would show my comment replies correctly, I decided to open the file on my phone to see if it worked. And in Acrobat's mobile app, it worked perfectly.

Not only did the file – or enough of the file for me to work with – load instantly, but the comment and reply tool was elegant and simple. I could work through the edits ten times as quickly as I could on my laptop, all without crying in frustration.

There's probably a setting in the desktop, Windows-based version of Acrobat that would have made this PDF commenting task just as breezy. But I couldn't find it before I lost my mind. This shouldn't be so difficult; software should work as smoothly for first-timers as for advanced users. To be clear, I don't mean specialist tools but generalist, mainstream applications – I get that the software that runs, say, a nuclear power plant might require some pre-training before logging in.

To me, Microsoft Excel and Google Sheets largely get this right. Anyone with basic spreadsheet skills can tot up a list of numbers without feeling like their brains are going to melt, while advanced users can manage company budgets.

Microsoft Word used to be like this, but today its overfilled menus leave me feeling overwhelmed. I spent decades of my life using Word but ditched it years ago in favour of Google Docs, largely because of cost. But when I needed to work through edits on the book last year, I couldn't get the 350-page file to open in Docs without crashing.

I paid for a month's subscription to Word, but while the file opened I was utterly bewildered by what I saw, with yellow bubbles and lines criss-crossing

the document. I couldn't unpick the settings to make them work for me. Eventually, I figured out the file would work if I exported it into Google Docs, and that largely solved the issue.

A few months later, I opened Word with the same big file to remind

“I increasingly feel like I need someone to hold my hand whenever I open software I haven't used in a while”

myself of the horror... and the yellow lines were gone. The comment function looked largely like Docs, with a little blue popup announcing the feature had been updated. (Apparently this is “Modern Comments” and it happened in 2022, so I have no idea why my file opened the old way the last time.) Although I'm sure some despise the update, it works for me – though I increasingly feel like I need someone to hold my hand whenever I open software I haven't used in a while.

And that's why, beyond software that just works without thought, I want an AI “Clippy”. I'm hoping Microsoft, Google, Adobe and the rest use their obsession with AI to simplify or explain their software with such tools. Imagine if Word could ditch all the dropdown menus in favour of natural language search, letting you pin your most used options in a way that works for you. Or if AI-enhanced telemetry noticed that my document kept crashing and so might benefit from conversion to a different file type.


Whether or not that comes with an animated paperclip, it would make my life a lot easier. And at least I'd have someone to talk to while melting down in frustration.

 work@nicolekobie.com



AI PC? Remind me why I want one...



Barry Collins can vaguely remember that he used to edit *PC Pro*. Email him at barry@mediabc.co.uk if he's forgotten to do something.
 @bazzacollins

We think of computer memory as bytes on a stick of RAM, but if Barry has his way then future AI PCs will bring a whole new meaning

For the past few months, I feel like I've been living the inverse of Monty Python's "What have the Romans ever done for us?" sketch. Every time I've been at a press conference where a PC manufacturer has launched a new AI PC I've asked the question: what's it going to do for us? The answer: blur the background of our video calls without smashing the granny out of your CPU. Er... that's it.

Okay, that's a slight exaggeration. There are practical benefits to having a neural processing unit (NPU) inside your PC today – as you'll discover in our feature on p28 – but it's safe to say that the real advantages of AI PCs are yet to reveal themselves. The hardware's on the market, now the software developers must work out what to do with it. If you're buying one now, you're future-proofing yourself for brilliant apps that might take full advantage of that NPU in the next few years, rather than lording it over the plebs that only have a CPU and GPU to play with.

While the PC manufacturers are scrabbling around trying to find reasons to make us buy an AI PC so they can deliver the massive sales uptick they've promised their shareholders, I know exactly what I want one to deliver: a safety net for my faltering memory.

Anyone who's worked with me for any length of time will know my memory's not the greatest. I've never had one of those brains where information just sticks. I always struggled to learn the lines for the school play, was hopeless at memorising chess openings, had to

revise harder than anyone I knew to get a decent score in exams.

I've always thought it dreadfully unfair that you can't just swap out parts of human memory in the same way as you can a computer's. I don't need to remember my nan's old phone number or the lyrics to "Agadoo" any more, but I can. Why can't I overwrite them with my other half's mobile number, or the category I'm meant to tag my train fare expenses with in Xero? Something that might actually come in useful in 2024?

I'll tell you what does know this valuable information, and much more besides: my laptop. But dredging that knowledge from storage can be a chore.

To give you a recent example. As I write this, editor Tim's out in Barcelona at Mobile World Congress and he's just pinged me on Slack to ask if I have the mobile number of a mutual PR acquaintance that he's meant to be meeting out there. So off I pop into Outlook to see if I can find an email from said PR, open it up and scroll down to his email signature where indeed he's been considerate enough to include his mobile number. Copy and paste, job done.

But wouldn't life be much easier if I could simply ask my AI PC: what's Andy McMegaphone's mobile number? (Some names in this story have been changed to protect the identity of those involved.)

Likewise if I wanted to check if I'd ever written a column about AI before, or if I had an image of a badger in my photo collection, or which dates I said I'd be free to join a *PC Pro*

podcast for in April. All of this information is trapped on an SSD somewhere,

“An NPU should be able to root through the vast swathes of data stored on my laptop and answer questions within seconds”

in a form that any half-intelligent AI could easily decipher. But right now I have to dive into individual apps with often erratic search facilities in a time-consuming attempt to find it.

That's even assuming I remember which app I lodged that information with in the first place. Countless times I've trawled email, Slack, WhatsApp and Twitter DMs in turn, desperately searching for a snatched fragment of conversation I know I had, but can't recall where.

My laptop is an extension of my memory. The reason I don't delete any email that contains even the faintest glimmer of useful information is because I might need to refer to it at some point in the future. I can't possibly remember what code Tim told me to put on my invoices six months ago, but an NPU should (with permission) be able to root through the vast swathes of data stored on my laptop and answer that question within seconds. An AI PC with that capability would be absolutely game-changing, saving me huge amounts of time and toil. And it's well within AI's current capabilities. I'm not asking for the moon on a cocktail stick.

So, no, hand on heart, I wouldn't advise anyone who doesn't otherwise need an upgrade to go out and buy an AI PC now. The benefits are too slim. But when I think about the potential for what an AI PC might be capable of in a year or two's time? Well... it's enough to blow my already forgetful mind.

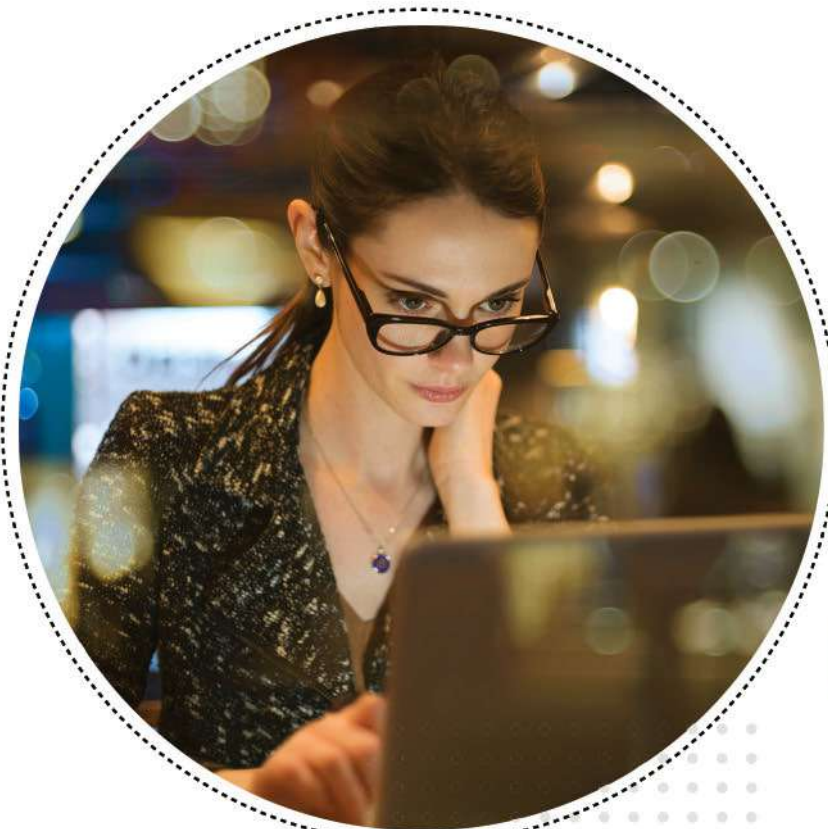
 barry@mediabc.co.uk

“I don't need to remember my nan's old phone number or the lyrics to “Agadoo” any more, but I can. Why can't I overwrite them?”

Combat unknown unknowns with **full-stack observability.**

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your applications, infrastructure, and networks for
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IT admins worldwide





Readers' comments

Your views and feedback from email and the web

Ultimate advice

Your review of Avast Ultimate (see issue 355, p84) reassures me that I have no need to think about changing my antivirus software.

In the final column of the review, you mention your entirely reasonable annoyance at banner ads that prompt users to purchase additional apps such as Avast Breach Guard and Avast Driver Updater. Users can disable such pop-up ads in the configuration menu for Avast Premium Security. Head to Menu | Settings | Personal Privacy | Offers and then just untick the two boxes in that section, as shown in the screenshot.

Simple!

Raymond Dalglish

Second-hand thinking

Have you ever featured an article on buying second-hand computers and components? As a budget-conscious PC user, I am often tempted by second-hand PCs and parts but am unsure if buying such makes sense. I like the idea of recycling and reducing landfill, but not at the cost of productivity and reliability. What are the positives and the pitfalls of used machines and parts? An article on this topic would be most helpful.

Simon Unwin

Editor-in-chief Tim Danton responds: The simple answer is yes, and as luck would have it Lee Grant covers the pros and cons of buying refurbished PCs this month (see p34). (To anyone suspicious about such things, no, Simon's letter is not a plant!)

Offers

If you're interested in receiving offers for related products and services.

- ☐ Share app-usage data with Avast so we may offer you upgrades or our other products.
- ☐ Share app-usage data with Avast so we may offer you 3rd party products.

ABOVE Blocking the ads in your antivirus software can lead to Avast improvement

We also wrote a feature about buying second-hand PCs back in 2019. If you subscribe, you can access it via the apps or at magazine.pcpro.co.uk. Head to issue 299, turn to p28, and you can read further tips on buying a second-hand PC.

Every little helps

I'd like to offer Farley David and Peter Sherwood some help in making their supermarket shopping easier (see *Readers' comments*, issues 354 and 355 respectively). The Tesco smartphone app has a facility for searching for a particular item and, alongside the item, it displays which aisle you can find it in. Also, there's a Shopping List section where you can choose items to build your list – at the top of the list is a toggle for “Sort shopping list by aisle”. So to claim that no stores have offered a technical solution for making your shopping easier is not quite right – it's here!

John Clifton, Smile IT Ltd

Just the business

I've been using consumer Netgear mesh Wi-Fi systems for a few years, but where I'm now living in France presents some problems. My office is in a different building to the house, a gite, some of the walls are two-foot

thick as the house dates back 350 years and the gite used to be a barn, and the garden in which I spend a lot of time is a funny shape and has lots of blind spots. So the Netgear outdoor extenders never worked reliably, and last year would barely work at all, despite costing hundreds of pounds each.

Being very aware of the risks posed by unpatched IoT devices I wanted more security and more control; I already have a Netgear appliance on the network for this. So I consulted with a tech friend and he recommended the TP-Link Omada Mesh system, which is a business solution. TP-Link's extenders, indoor and outdoor, are all hard-wired which was the way I wanted to go, and being business kit they're far more fully featured when it comes to management and security.

Imagine my surprise, then, when the business-class kit came in at around half the price of the less capable consumer equivalent. I should have gone this way in the first place. I think this is definitely worth a Labs or a feature in *PC Pro*, as I'd love to hear your thoughts on it.

Mike Halsey

Editor-in-chief Tim Danton: Thanks Mike. I've spoken to Darien about this and we will definitely cover the topic of using business rather than consumer hardware in the future. Jon Honeyball's RWC column (see p110) is also a valuable resource on this, as he often writes about using business hardware in a domestic environment.

Star letter

Laptop lite

Regarding the request of your reader Michael Albin (see issue 355, p24) for a laptop without a screen or keyboard, perhaps he might consider a mini PC? Minisforum, Geekom and ASRock all offer very compact and high performance units. It must be said, however, that my Minsforum adventure ended badly, with the motherboard failing after nine months. Fortunately, I was able



to transplant the CPU, memory and SSD into an ASRock x300 unit, and that's been rock solid from day one.

David Evans

By the way, a future article comparing mini PC products would be of great interest. I'm already looking at an ASRock DeskMeet x600 for my next system, as this can accommodate a discrete GPU card.

Editor-in-chief Tim Danton replies: Thanks for your email, David. Of course, the one missing component in mini PCs is a battery, but I definitely take your point and am a fan of mini PCs myself. I think you're right that it's high time we took another look at this computing form factor, so look out for a group test in a future issue.

I'm also interested in how people are using mini PCs, so if you've bought one (or are thinking of buying one) please get in touch by emailing letters@pcpro.co.uk.



This month's star letter writer wins a Cherry KC 200 MX mechanical keyboard, worth £80, recipient of a five-star review and a *PC Pro* Recommended award. Email letters@pcpro.co.uk

Fibre diet

Should you upgrade to gigabit broadband (see *issue 355, p34*)? The simple answer is yes, not just because it's the latest technology, but because it's a proven and stable technology that has been around a while and has matured into a technology that speeds up access to the internet and allows more people in a household to do more without worrying about running out of bandwidth.

Who to choose as your internet service provider is a gamble, as covered by Barry's feature last month. Do you go for a big name or do you go for the latest startup? Dealing with a big provider has its benefits and drawbacks: they should be around for a long time and will have a mature service offering, but when things go wrong they can be hard to deal with. Going for the latest startup usually means a cutting-edge technology boost and quick access to problem solving; the downside could mean that they don't last long before they go bust or get taken over.

The problem with the current gigabit broadband market is that you have plenty of options but you find that they all want to install their own equipment and ducting. Locally, I found that I had six options to choose from: we have Virgin with its historic ductwork, while three different startup fibre companies each have their own ductwork, which has led to most local pavements now being hollow. Another company uses telegraph poles to hang its fibre cables, from which it then supplies homes with Wi-Fi-based broadband.

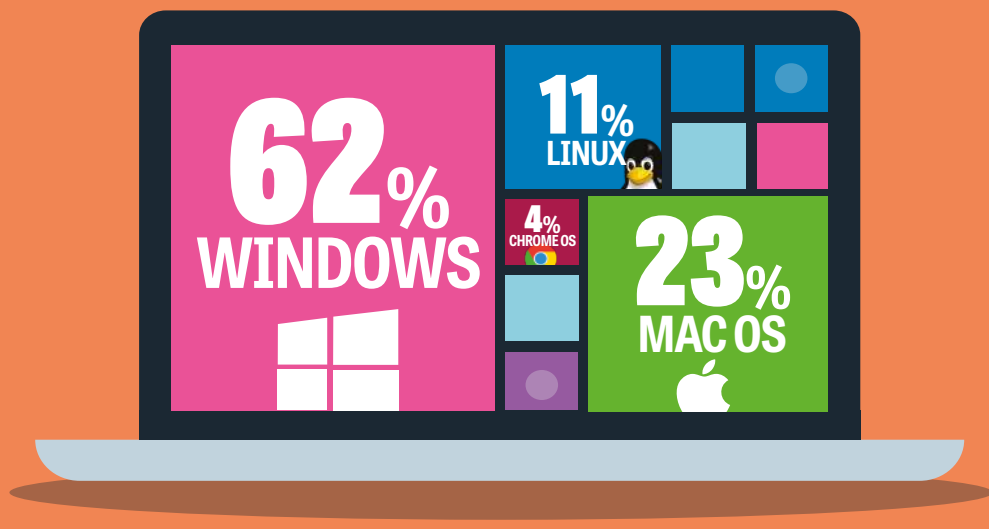
Having weighed up all options last year, when I found out that some providers would not go live for a good amount of time, I went for Vodafone (whom I was already with for broadband, landline and mobile), which was piggybacking off of BT Openreach, which had already wired up my nearest telephone pole. They quickly installed directly to my small home server rack.

BT Openreach is currently changing the whole of the UK's copper telephone network over to fibre and could easily become the dominant player in the market. It could price the competition out of the market, although what the Competition Commission would say about this would surely not be favourable.

Michael Ashworth

Readers' poll

Which OS are you most likely to choose for your next computer?



Thanks to everyone who took part in our poll across Facebook and X, and what an interesting set of results it is. Bad news for Chrome OS, but perhaps our group test of the latest Chromebooks will persuade you otherwise (see p78). Good news, however, for virtually everyone else: macOS goes from strength to strength, that's the strongest vote of confidence in Linux we've yet seen, while Microsoft remains the dominant force.

But it's not as if everyone is wildly enthusiastic about Windows. We can almost hear John Gwatkin-Williams' sighs as he wrote: "Definitely Windows. I'm just too invested in it to want to change." This was echoed by @ToulouseTommie on X. "Windows, boringly. It's for work, not play."

Adam Jackson, however, is moving to macOS. "I have a Windows PC as well as a Mac, but every time I use Windows it makes me contemplate just how much a flight to Dignitas would cost so I could get some blessed relief from it."

But we'll leave the last words to Rachel Crowther. "I'll be trying Linux as the bare-metal OS with CrossOver plus a Windows VM [for running Office]. I want an OS that will never, ever update and restart without my permission; I want a system I can audit for security; and I want a system that understands minimal mouse movement and where I can hack at window manager bindings." Rachel adds: "It used to be that Microsoft wanted my money, Google wanted my personal data, and Apple wanted my soul. Now Microsoft wants my money, my personal data, and control of my hardware; Google wants my personal data and control of my hardware; and Apple wants my money and my soul. I choose 'none of the above'."

“Windows. It might be the VHS of the operating system market, but we know what happened to Betamax.” **Paul Bamberger**

“Windows for me. It's still the most compatible with Steam and PC gaming.” **Simon Mellor**

“I'm just really enjoying my first Mac so will probably get another when the time comes – although I do miss Windows Explorer.” **Benito Aramando**

“Linux: a fast, secure, stable operating system.” **@gurnaik**

“Windows. 30+ years of muscle memory and it's good enough.” **Mike Gannon**

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AI PCs

WHAT YOU NEED TO KNOW

Microsoft, AMD and Intel are all pushing the idea of AI PCs, but is it anything more than marketing-speak? We find out

CONTRIBUTORS: Barry Collins, Tim Danton

Remember when 3D screens were the next big thing? What about virtual reality? Or 5G? The truth is that the technology industry loves buzzwords almost as much as it loves the tech itself, and its latest crush is AI PCs.

But here's the thing: if you ask five different vendors what an AI PC is you'd get five different answers. AMD and Intel will explain that it's all about their new silicon, which now includes neural processing units to go along with CPUs. Nvidia will point to its hugely powerful RTX GPUs. Microsoft will tout its mix of remote and local platforms.

Truth is, the definition is hazy. By some definitions, you already have an AI PC to hand via the mobile phone in your



ABOVE Google's Magic Eraser is AI on your phone, and it's available right now

pocket. It's personal, it computes, and if it's a recent Apple, Google or Samsung phone then it includes plenty of AI-enhanced features. Magic Eraser is one obvious example.

So let's lay down a simple working definition. An AI PC – for the duration of these six pages, at least – is a laptop or desktop PC that includes a processor with a neural processing unit (NPU). That means an Intel Core Ultra, any AMD Ryzen processor with Ryzen AI

built in, and Apple MacBooks and Mac desktops with an M1, M2 or M3 series chip.

With that settled, let's get to work. What's the point of an AI PC? What can it actually do? What options are available? And, the fundamental question, should you buy one?

WHAT CAN AN AI PC DO NOW?

If you're in the market for a new PC and are weighing up whether to invest in a so-called AI PC, you might reasonably wonder what advantages it will bring over an "ordinary" PC.

We'll come to the benefits afforded by the piece of hardware that pretty much defines an AI PC – the neural processing unit or NPU – shortly, but there's another distinguishing piece of hardware found on many AI PCs: the Copilot key.

Calling for a Copilot

The Copilot key was billed as the first major change to PC keyboard layouts in almost 30 years, replacing the menu key to the right-hand side of the spacebar. It's basically a shortcut for opening the Copilot assistant in Windows 11, sparing you the enormous effort of using the current Windows+C shortcut. "We're excited about having this key on our systems," said Kevin Terwilliger, vice president and general manager of Dell's Latitude and docking business on a recent AI webinar. Indeed, it was the first thing Dell's guide showed us when we visited the company's stand at MWC (see our highlights on p14).



ABOVE The Copilot key can be found on most AI PC laptops, including this Dell Latitude 9450

People are going to be interacting with Copilot throughout their day, engaging with it, asking questions, working with it to create content

While enthusiasm levels among PC Pro's professional readership might be a little more muted, it's worth remembering that 99% of users aren't familiar with any but the most basic keyboard shortcuts and that such initiatives – while appearing cosmetic and trivial – could make a difference.

"We really think of Copilot as the new search," said Terwilliger. "And people are going to be interacting with Copilot throughout their day, engaging with it, asking questions, working with it to create content. And so we think the fact that having that key on the keyboard to jump-start access into Copilot will be very valuable for the end user."

Microsoft is driving Copilot integration deeper into the operating system, too. At the time of writing, Copilot's ability to control the PC is limited. It can help you flick into dark mode, take a screenshot and open File Explorer, but it's superficial stuff.

However, Windows Insider releases launched at the time of writing show Microsoft continuing to build out Copilot's system-level capabilities, allowing Copilot to show available Wi-Fi networks, clean storage, show which apps are set to run on startup and more.

Again, enthusiasts and IT pros will barely raise an eyebrow, not needing Copilot's help to perform such tasks. But it could (and we stress "could") make a big impact with mainstream users who aren't as familiar with the workings of Windows. And if it spares IT departments from dealing with these more low-level queries, allowing more time to focus on the business-changing stuff, that can't be a bad thing, surely?

What does the NPU do?

The NPU is the core component of an AI PC, the factor that really sets it apart from a PC with only CPU and GPU units to call upon. Over time, it's likely all PCs will ship with an NPU (see box, p30), but for now they're the key differentiating factor.

But if you're an early adopter, one who rushed out to buy a laptop or PC with an NPU-blessed Intel Core Ultra or AMD Ryzen chip inside, what benefits will you feel right now, today? Even the PC manufacturers quietly concede the advantages are slim pickings at the moment.

One that crops up often in PC manufacturer demos is the NPU's ability to blur the background on video calls. Most users won't care if it's the CPU, GPU or NPU that performs something as mundane as background blurring, but it can make a difference to power consumption.

Dell ran a demo showing background blur being applied on a Zoom call on an ordinary PC, where CPU utilisation shot up to more than 8% when the background blur was applied. By applying the same effect locally on the NPU, using Windows Studio Effects, the CPU was barely troubled at 1% utilisation. "This actually translates into a 38% power improvement when you're doing



LEFT The NPU can be used to blur the background in video calls

these Zoom calls,” claimed Kevin Terwilliger. “So collaboration is a great area where we’ll take advantage of the NPU to deliver energy efficiency and much longer battery life.”

That’s fine, but it’s hard to believe anyone’s going to buy a new laptop to save a slice of battery life when using background blur on battery power. Is anything more substantial on offer?

Dell points to security benefits, claiming the NPU is better placed to deal with threat detection. The firm ran a demo of an unnamed security package, but instead of running threat detection in the cloud, it used a local engine on the NPU. Dell claims the threat detection on the AI PC kicked in within 20 milliseconds, a 70% improvement in latency compared to the cloud. “Our goal is to not talk about the hype of AI, but show examples just like this to our customers so that they can understand the value of the NPU,” said Terwilliger.

You’re not racing off to the Dell website to order an AI PC yet? Maybe a more creative application will convince you, and here the benefits are arguably more substantial. Instead of relying on expensive cloud services such as OpenAI’s DALL-E or Midjourney to generate images, you could install open-source models such as Stable Diffusion and run them locally instead.

You can, of course, do that already on a PC without a NPU. But Charlie Walker, Dell’s senior director and GM for Precision workstations, claims it’s much faster with the NPU involved. “If I tried to run Stable Diffusion on my CPU, previously it would have taken two to three minutes [to generate an image],” he said. “Now with the NPU, by offloading that from the CPU into that more efficient architecture... you can do that now in 30 to 50 seconds. So again, significant savings.”

The obvious downside? That only more technical users will feel comfortable downloading open-source projects such as Stable Diffusion, despite many in-depth guides online to step you through the process. For local AI to break through, it needs to be simple.

WHAT WILL AI PCs DO IN THE FUTURE?

There are benefits to owning an AI PC now, but those benefits range somewhere between niche and slight. However, there’s almost universal industry agreement that those benefits will rapidly increase well within the lifetime of the average PC.

“What you’re doing on an AI PC in 2024 is going to be radically different to 2026,” said Intel’s executive vice president for client computing, Michelle Johnston Holthaus, at CES in January, a sentiment with which the company’s chief rival agreed. “It will probably be the end of 2025 before you really start to see what an

AI PC is capable of,” said AMD’s senior processor technical marketing manager, Donny Woligroski.

“The GPU is currently the fastest AI processing unit,” Woligroski added. “You’re going to see that performance cross over, with the NPU doing the same levels of [AI] performance as the GPU.”

Lenovo agrees the best is yet to come from AI PCs, pointing out that the software developers have only just started working with production hardware. “It’s almost a chicken and the egg,” said Tom Butler, the company’s executive director of commercial portfolio and product management. “I’ve got to have hardware out there that can catch the software benefits.”

He added: “The front end of this wave is hardware driven, because there was nothing for the software to write to, because a lot of this was in the labs of the silicon providers and OEMs like Lenovo. We couldn’t go out broadly and have these discussions with software companies.”

Now, according to Butler, “we’re actively in conversations with a broad breadth of software companies. We are, the silicon providers are, basically everybody’s looking at this new space to see ‘what can I do now?’”

The pace of product development in the AI industry has been nothing short of breakneck. Subscribe to the Ben’s Bites newsletter ([bensbites](#)).

RIGHT Intel CEO Pat Gelsinger is betting “this big” on AI PCs



Will all PCs be AI PCs?

Far be it from us to suggest that the label “AI PC” has been co-opted to help drive PC sales, but that noise you can hear is the sound of PC sales managers rubbing their hands together in glee.

Is the AI PC label likely to be around for long? Will manufacturers sell ranges of AI PCs and ordinary PCs side by side? Or will an NPU become as standard as the GPU (integrated or otherwise)?

Dell certainly doesn’t think the distinction will last much beyond the short to medium term. “For the time being, I think there are going to be two versions [of PCs],” said Meghana Patwardhan, vice president of commercial client products at Dell. “If you think about all of the desktop market, [it’s] still not fully on NPU at this point of time.

“Eventually, I believe that our customers are going to adopt AI across the board and you are going to see whether it’s building your own large language models and making use of the NPU on the PC, whether it’s using [a third-party] application, whether it’s using what Microsoft or Google or others are developing, every PC is going to be an AI PC in the longer term.”



ABOVE Intel's Core Ultra chips are being used by over 100 software developers

beehiiv.com), for example, and you'll find multiple new AI product launches announced every day. Butler predicts you won't have to wait too long to see exciting new product launches that tap the capabilities of AI PCs, either. "I think if you just project forward near term – like in months, quarters, not years – you're going to see a lot more capability coming," he said.

Dell's Kevin Terwilliger agrees that we're only just getting started with AI PC apps. "We're just at the tip of the spear when it comes to all these AI capabilities," he said. "Intel has

and writing emails, all without data being sucked into the cloud.

Currently, it only plans to release AI Now in China, but it's indicative of a coming shift from cloud to local AI processing. "If you think about AI in general right now, most of it is cloud-based," said Butler. "And that opens up latency concerns, security and privacy concerns. And so the ability to bring that down to the edge device not only overcomes some of those hurdles, but it also makes it more personal, like you're working on your work for you, not a broad, open public cloud-based platform."

It will probably be the end of 2025 before you really start to see what an AI PC is capable of

talked about the 100+ ISVs [software developers] that are utilising the Core Ultra processor. And then what we also see as a great example, companies like Dell, large organisations, are developing new AI capabilities to roll out to their end users internally. That's going to take advantage of this NPU to be able to run efficiently and not have to move a bunch of data into the cloud."

Lenovo isn't planning to leave it to third-party developers to come up with AI software, either. At CES it showed off prototypes of its own AI apps that took advantage of the NPU, instead of relying on the cloud. The company's AI Now platform includes a Windows Copilot rival that is able to alter operating system functions, as well as perform tasks such as summarising long documents

A big advantage of local AI software is that it could access the different apps and data piles stored on your PC, rather than being restricted to files that you upload to the cloud. Butler said you can think of this as an "orchestration layer", capable of bringing together the capabilities of different apps, working with system-wide data. "It's almost at that point a prompt-led conversation with your system, not 'let me open this app to accomplish a task'."

He envisages a future where you'll tell the AI that you want to accomplish a specific task and it will tell you the best, most efficient path to achieve that using the resources and apps you have available on your particular PC. "That's not in the market or present today, but that's effectively what you want to drive to from an AI perspective," he said.

The easy way to run LLMs locally

It's a misconception that you need the huge processing power of cloud servers to run large language models (LLMs). It's possible to run LLMs locally on relatively modestly powered PCs, even without an NPU or dedicated graphics.

If you've ever tried to download and run an LLM locally, you may have been put off by the need for prerequisites, environments and web UIs to make it all work. However, there is an easier way.

The free LM Studio (lmstudio.ai) for Windows, Mac or Linux lets you download and run LLMs without any of the faff. You simply choose which LLM you want to run, either by picking from a selection on the home screen or typing its name into the search bar, and it downloads and runs them.

At the time of writing, available LLMs included Google's recently released Gemma, Qwen from the Alibaba group, and Code Llama from Meta. LM Studio gives handy descriptions of the LLMs featured on the homepage to help you choose, as well as details of how much memory they'll require to run and the size of the download. Most LLMs are between 2-10GB.

Once you've made your choice, click on the Chat icon on the left, select the model you want to interact with and start chatting away. (If you can't see the USER chat field, close the download pane in the bottom half of the screen to reveal it.)

On the right-hand side, you should be able to access the LLMs settings. Here you can normally enter a system or pre-prompt that tells the LLM how you want it to behave. For example, "Give answers as if explaining to a five-year-old" or "assume technical knowledge". You can also choose the level of GPU acceleration, prompt overflow settings and more.

Chatting with local LLMs requires a different mindset to using ChatGPT, Copilot or Google Gemini, which have access to live internet data. Its knowledge will be limited to the recency of its training data. For example, Meta's Llama 2 model told us Boris Johnson was the "current Prime Minister of the United Kingdom", while Google Gemini replied "As of October 26, 2023, the UK Prime Minister is Rishi Sunak". Bear in mind it's at least two weeks since we wrote this copy by the time you're reading it, so we could be another two PMs down the line by now...

But, as we've discussed many times before, using these AI engines as fact checkers/search engines is a bad idea in the first place. They're more useful for generating text (give it a few bullet points, let the AI put it into prose) or writing code than acting as a pseudo-Google. And these local LLMs are more than capable of these more basic tasks, and won't cost you a penny to run either.



ABOVE LM Studio is free and lets you download and run LLMs on your own local PC



AI PCs YOU CAN BUY RIGHT NOW

Apple MacBook Air

From £999 from apple.com/uk

We review the updated M3 version of the MacBook Air this month (see p54), but the M2-powered version for £999 uses the same 16-core Neural Engine as its more expensive siblings. It's actually the 10-core GPU (rather than the standard 8-core) that could make the most notable difference in AI applications.

The Air series is only the cheapest MacBook, of course. At the other end of the extreme, you can buy an M3 Max-powered 14in MacBook Pro from £3,299, where you'll benefit from the extra horsepower of a 14-core CPU and thunderous 30-core GPU.



Apple iMac

From £1,399 from apple.com/uk

Apple recently updated its 24in iMac with M3 chips, so you will again benefit from its 16-core NPU alongside the latest Apple silicon. As with the MacBook Air, you can upgrade to a 10-core GPU rather than 8-core for a rather stiff £200, but this gives the benefit of two more USB ports, 1Gbit Ethernet and a Magic Keyboard with Touch ID.

As we mentioned in our review (see issue 352, p52), the high price (especially once you start adding more storage and memory) count against this stylish all-in-one, but you can't argue with its quality.

Asus Zenbook Duo UX8406 (2024)

From £1,700 from currys.co.uk

Here's something a little different: a two-screen laptop to rival the likes of HP's Spectre Fold 17 (see p52).

Except here you reap the benefit of a Core Ultra chip, either the Ultra 7 155H for £1,700 or the Ultra 9 185H for £2,000, and with it some considerable AI potential. Much more than the relatively slow 12th gen Core chips found inside foldable laptops.

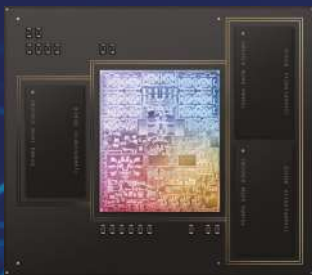
As with the Spectre Fold, you can use the Duo in various modes, but it's at its best when you need a main window and a supplementary one. Great for debugging AI programs, perhaps. But we also think it works well as a normal laptop, as the detachable keyboard sits snugly on the base. We reviewed it last month from p60. Our only note of caution is that stock remains thin on the ground.



The processors powering AI PCs

We've all become used to cores and gigahertz as the key stats for processors, but as we slide deeper into 2024 that is set to change. Now, the silicon makers are starting to talk about TOPS, which stands for trillions (or tera) operations per second. The sheer magnitude of the number here gives you some idea of AI PCs' potential power, as – in the right situation – they can achieve so much in a fraction of a second.

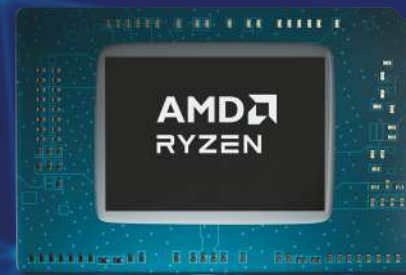
Here, we provide a quick look at what AMD, Apple, Intel and Qualcomm have to offer with their latest processors.



APPLE M3

18 TOPS (NPU only)

When it comes to NPUs built into silicon, Apple had a head start on its rivals. The M1 appeared in 2020, and while Apple didn't state its power the internet's best guess (from @t3mporaryblp on X) is 11.3 TOPS. It's perhaps surprising, then, that the M3 is stuck on 18 TOPS. Apple claims the new MacBook Air (see p54) is the "world's best consumer laptop for AI". While that may not be true of the hardware, Apple can rely on a strong software ecosystem, not least because developers have been exploiting the Neural Engine for so long.



AMD RYZEN 7040 AND 8040 SERIES

7040: 33 TOPS 8040: 39 TOPS

AMD beat Intel to the AI punch by almost a year, with its CEO Lisa Su announcing the Ryzen 7040 series way back in January 2023 and the first laptops available by March last year. Then in December, it announced the updated 8040 series, with the promise of a slight boost in performance, too. It's a little confusing, as not every 7040 and 8040 series chip includes Ryzen AI – AMD's name for its NPU – so you should check each processor's listing before buying.

PCSpecialist Fusion Elite P

£649 from pcspecialist.co.uk/reviews

This is one of the most affordable ways to buy an AI PC today, being based on AMD's Ryzen 8600G chip. It comes with respectable integrated graphics, and the latest Ryzen AI with the promise of 16 TOPS

speeds, and unlike all the laptops on this page there's room to grow. When budget allows, simply slip a graphics card into the waiting slot.

Surprisingly for the price, you get liquid cooling for the AMD processor, which not only helps maximise its performance but also keeps the noise

volume down. So while this PC isn't the height of luxury or expandability due to the budget microATX motherboard, it's a cracking way to start an AI adventure. Read our full review in issue 355, p54.

Acer Swift Edge 16

£1,299 from currys.co.uk

This was the first laptop we reviewed with AMD's Ryzen 7 7840U chip inside (see issue 351, p42), and it remains something of a beauty. While the name leads on its slimness – a remarkable 13mm – what struck us most on use was its 1.2kg weight. That came at the expense of battery life, with eight hours in our tests, but that compromise was inevitable. Other than this, compromise isn't in



the Edge 16's vocabulary. From the 1440p webcam to the fit and finish, this is a top-quality laptop – and you simply can't argue with that price.

Framework Laptop 16

From £1,699 (pre-built) from frame.work

Whether you want a laptop that will last for a decade or simply desire a number pad that can be fitted on both the right and the left, this modular laptop is like no other. We provided an in-depth review last month (see issue 355, p68), where it



earned a five-star review for its quality as well as its repairability.

What makes it an AI PC is AMD's Ryzen 7840HS processor (you can choose a Ryzen 9 7940HS too), and with the option of adding an extra 6TB of storage via expansion cards it has the potential to handle even the most demanding of masters.

Samsung Galaxy Book4 Pro 16in

512GB, £1,699 from samsung.com/uk

Intel's Core Ultra range was only launched in December, but there's no shortage of laptops powered by its chips. For example, this month we review the updated Dell XPS 14 (see p48) and we can confidently predict that dozens of laptops we review this year will include various versions of the processor.

Samsung has also updated its Book range of laptops with Core Ultra CPUs, so if you see Book4 in the name you know it's an AI PC. We reviewed the Book4 Pro 16in last month (see issue 355, p64), and it's one of the best: despite the 16in OLED panel, it's a sleek 12.5mm thick and exudes industrial chic thanks to its all-metal shell. ●



AMD RYZEN 8600G AND 8700G

39 TOPS

AMD has also beaten Intel to the desktop punch when it comes to NPUs built into silicon, announcing the Ryzen 8600G and 8700G chips at CES 2024 in January. Just to muddy things a little, the 8500G and 8300G – announced at the same time – don't include Ryzen AI. We've already reviewed a PC based on the 8600G, the PCSpecialist Fusion Elite P, which we cover above. At £649, it's an extremely affordable entry into the AI PC world.



INTEL CORE ULTRA

34 TOPS

Launched in December 2023, Intel's Core Ultra chips were the company's first to feature an NPU. Only 11 Core Ultra processors have been released so far, ranging from the Ultra 5 125U to the Ultra 9 185H, but they're proving incredibly popular with laptop makers: we're already seeing a flurry of machines built on the chips, and Intel reportedly hopes to sell 100 million Core Ultra PCs by 2025. Note that Intel doesn't give its NPU an individual TOPS rating, with its 34 TOPS claim based on the CPU, GPU and NPU combined.



QUALCOMM SNAPDRAGON X ELITE

75 TOPS

You'll have to wait until mid-2024 for the first AI PCs based on Qualcomm's all-new Snapdragon X Elite to appear, but it promises much. Indeed, at its October 2023 launch, the company claimed it offered "4.5x faster AI NPU processing power than competitors" with its Hexagon NPU capable of 45 TOPS on its own (75 TOPS once you include the CPU and GPU). That figure compared it to the 10 NPU TOPS of the Ryzen 7040, but AMD's Ryzen AI now offers 16 TOPS – still a big difference.

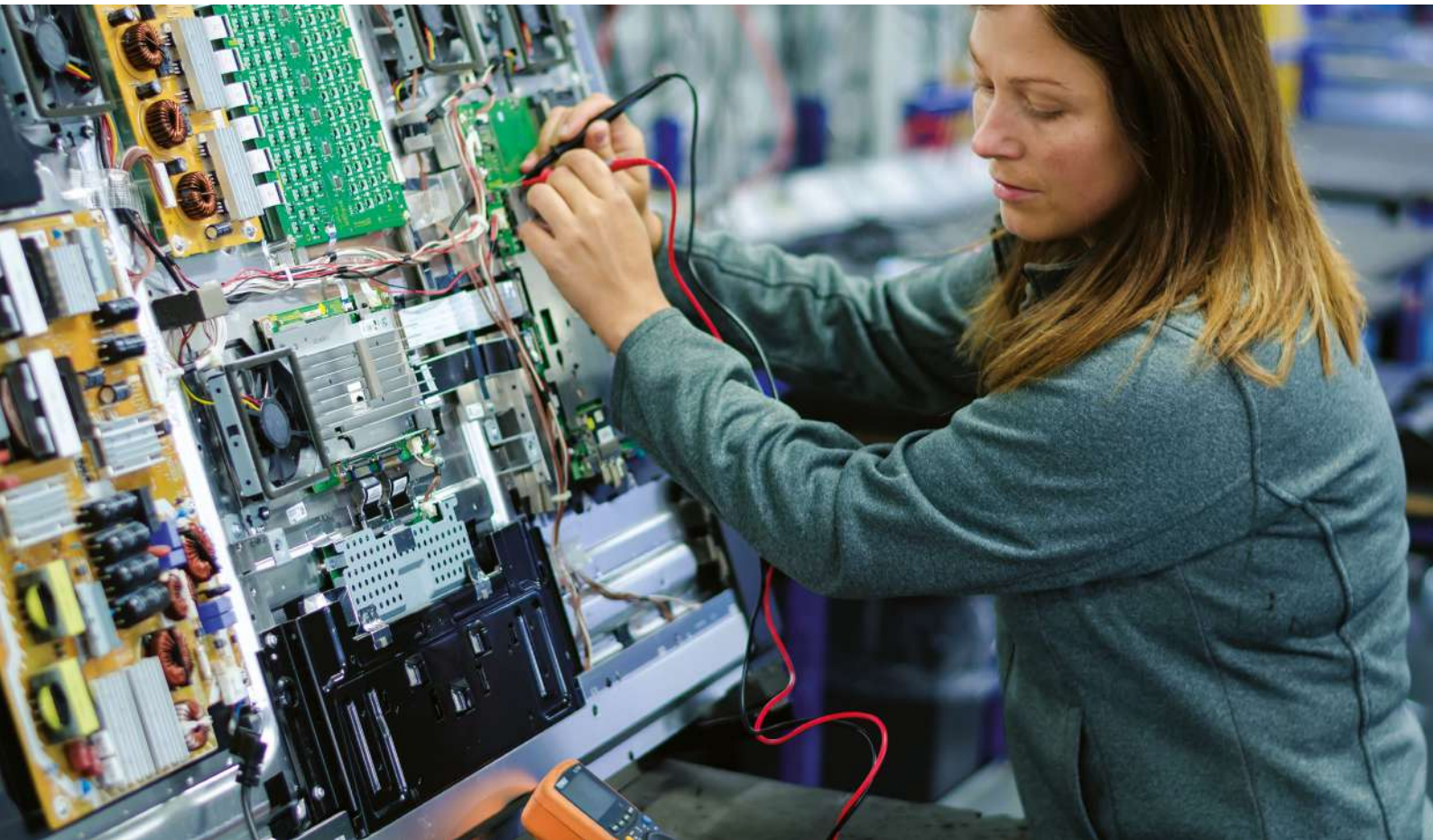


The truth about refurb

Refurbished tech has become a multi-billion industry, but does it offer good value? [Lee Grant](#) investigates



LEFT Many projects are ensuring that old PCs aren't simply left to die



Anyone looking for replacement tech will have spotted plenty of offers for refurbished devices nestling among the traditional adverts for new products. The refurbished electronics sector was valued at \$85.4 billion in 2021, according to Transparency Market Research, and is predicted to swell to more than \$250 billion within the decade. To put that into clearer context, more than half of all phones in circulation at the end of last year were second hand, according to estimates from analysts CCS Insight.

Refurb has matured from a jumble sale full of scratched screens and dead batteries to global names selling warranty-backed, risk-free products, giving customers access to top-tier tech at cheaper prices.

Although refurb looks impressive on corporate eco-credentials, forecasts state that the UK will still generate the highest amount of WEEE per capita globally in 2024. To understand why, we'll speak to sustainability experts to learn how refurb should be better integrated into the UK's circular economy and why we need to keep products in use for longer.

We'll also step into the workshops of professional refurbishers to see

how they're battling technology's short lifecycle in order to transform the retail landscape into a place where buying refurb is our default choice.

As good as renew

The Renew Hub in Manchester is a magical place. It's the UK's largest re-use facility, redirecting pre-used items through the hands of skilled refurbishers before going back on sale (tinyurl.com/356refurb).

It's industrial-scale refurbishment resourced by Manchester's authorities and waste management specialist, SUEZ. Furniture, bikes and household appliances are stripped, fixed, re-sprayed, re-upholstered, reimagined and reused.

The Renew Hub demonstrates refurb can deliver profit through retail while benefitting both environment and community. Over 20 green jobs have been created and its outreach teaches local schoolchildren about waste and refurb.

Since its inception, more than 180,000 items have passed through the Renew Hub, covering a wide range of product categories, but skills and

ABOVE Currys is investing heavily in refurbished tech

resources currently mean that laptops, phones or small electronic device aren't part of the project. Refurbishing technology is difficult, but one of the UK's biggest names in tech retail is embracing the challenge.

Although Currys has sold refurb on eBay for years, the offering wasn't even promoted on the company's website until February 2023. When it did get full promotion, 80% of the refurb stock sold in less than a week.

Stephen Hamid, Currys' senior development manager, admits the successful trial made the decision to push refurb much easier. "We have this usable inventory and it makes sense to sell it," he said. "Our research showed that consumers were more likely to buy second-hand tech than second-hand clothes, showing a real step change in how people think about refurbished electronics."

"Technology should have the longest possible life," added Hamid.

"Devices are valuable, material-rich products and if a customer upgrades a laptop, their existing device should be used again."

The UK will generate the highest amount of WEEE per capita globally in 2024



Where to find refurb bargains

Aside from refurb's environmental and social benefits, there's the undeniable benefit of getting top-notch tech at bargain prices.

Looking for a replacement iPhone? Back Market is selling the 128GB iPhone 13 for £361, compared to £599 at Apple. On Android? How about a 128GB Pixel 7 for £299 instead of £499? A new M3 MacBook Pro with 36GB of RAM and 1TB of storage is £3,299 from Apple, but Back Market can sell you the older 32GB M1 version for £1,910.

Refurbs are not only for Apple and Android. You can buy a HP Chromebook for £249 at John Lewis or get a refurbished version from Currys for £194. The 128GB Meta Quest 2 is £249 from the manufacturer, but Currys have refurbs for £219.

Don't forget that many manufacturers offer refurb, too. Microsoft sells a 1TB Xbox Series X for £419 compared to £469 new, while Amazon's 64GB Kindle Scribe (with Premium Pen) is £368 as a refurb or £409 new.

Remember, shop around and do your homework. It's a fast-paced sector so some of the products and prices may have changed by the time you read this, but refurb remains a fabulous way to get previous-generation top-spec products on the cheap.

To achieve this, Currys has invested in repair infrastructure. "We have the biggest electronics repair centre in Europe," said Hamid. "Over 1,200 technicians and within that, a smaller team who refurbish items for resale. We can take one product apart to harvest valuable components to be used in another product."

The team harvests parts from over 5,000 products each week, but Hamid acknowledges that not everything can be refurbished. "Even if a device is a few years old, we'll consider refurbishing it. We don't refurbish products damaged beyond repair or if the cost of parts is uneconomical, but the relationship we have with our partners and innovations, such as 3D printing, means we have incredible access to parts."

Certain gadgets are particularly tricky to refurbish – games controllers are a particular challenge. "The joysticks and triggers go through a whole other level of testing, but we have the capabilities to refurbish products to component level if needed," said Hamid.

The company is also conscious of data security when reselling refurbished kit, claiming any product it sells is "wiped to a government-approved standard".

"We test hardware and software before cleaning and repackaging," added Hamid. "We also have a separate function to double-check standards and quality."

The refurb pioneers

While Currys took a while to warm to refurbishment, RD-UK has been in the business for close to 15 years. Its founder, Nick Waite, spotted an opportunity to be different. "We were a distributor shipping CPUs and memory where the USP is price," he said. "There's not a lot you can do to differentiate yourself."

Waite realised that to persuade buyers to purchase refurb, it would take more than functionality to be appealing. "My hobby is restoring classic cars, so one of my guys brought me a battered desktop PC, which I put through my paint booth. He said, 'Fantastic. Can you do 50 more?'"

Since then, Waite's team has refined techniques to make refurbished products look like new. "We spent 18 months perfecting the vinyl wrapping process to give a durable finish while researching ways we could refinish keyboards," he said.

Just like new PCs rolling off a production line, the refurbished kit goes through a battery of tests. "We do a physical check to find damage that can't be refurbished, then break those down to make good from what we can, recycling stuff we can't use," said Waite. "All machines are cleaned and data-wiped before diagnostic software stress tests every component. Desktops may go to our paint booth, while laptops have their screens changed and batteries tested to ensure certain charge levels. Laptops are

vinyl wrapped, everything is re-covered, and keyboards are finished with UV technology. All products go through quality control before they're put in a new box, then it's back to the warehouse, ready for resale."

Waite is eager to dispel the notion that buying refurbished is as risky as buying a second-hand system off eBay. "Our refurbished products have the same warranty as when they were new, so no risk. Also, a new laptop generates 350kg of CO2 through production and distribution, compared to 50kg for a renewed product. They're buying a product that's like new, but greener."

The barriers to refurbishment

Even for large companies, certain products are hard to refurbish because the original manufacturers' software prevents the process. John Bumstead is a passionate refurber, specialising in Apple products for more than 15 years. "My favourite is the 2010 MacBook white unibody," he told us. "Even today, they still run a reasonably modern OS."

However, as the years have gone by, Apple has put more and more barriers in the way of the refurbishers. In 2016, it started soldering SSDs to the motherboard; 2018 saw the introduction of the T2 security chip and Activation Lock; and in 2020 it began pairing parts, preventing refurbishers from replacing dysfunctional parts of a device. "The current machines are beautiful, but they're an impossibility when it comes to refurbishing," said Bumstead.

Apple's current security software prevents unauthorised access to data, but if the original owner doesn't disable Activation Lock, the device is useless. The same applies to Apple devices controlled by large organisations. "An institution will put Remote Management on all their machines," said Bumstead. "It's based on serial numbers. Therefore, when you power on that machine, even if it's been wiped, Remote Management comes up and it's bricked."

John's workshop has hundreds of Apple devices that are unusable because of software and bureaucracy, rather than a physical fault. Although data should be safeguarded, John wants a flexible mechanism for refurbishers to unlock machines when an IT department has failed to decommission Remote Management. Until there's a workable solution, "millions of devices get destroyed".

John now focuses on machines where refurb isn't hobbled by the manufacturer. "Retro devices are easy," he said. "Everything is big and meant to last. I don't need a

microscope to see a Commodore 64 board. It's awesome!"

Pulling together

Innovating within the refurb space is the French company Back Market. It's a specialist tech marketplace that provides a shop-front for refurbishers to sell products. The company's UK general manager, Katy Medland, explained that not all applicants are accepted. "Sellers go through a rigorous onboarding programme, ensuring we're selecting the best," she said. "All devices go through a 25-point quality check with lots of mystery shopping and an open review system. Our quality team is one of our biggest teams, to make sure that people who are buying refurb have a good experience, like they're buying new."

That said, the company doesn't disguise the fact that these aren't products fresh off the manufacturing lines. "We're focused on ensuring that customers know what they're buying but we've tried to make it fun," said Medland. "Our marketing's far from standard, it's upbeat and quirky. We're presenting an old product in a way that consumers love, they really get it and they're educated about the benefits, price, quality, but also the environmental impact."

The firm doesn't wait for products to start hitting the second-hand market before working out how they can be refurbished. Back Market's Innovation Lab will "take apart new phones, working out the best way to refurbish, reassemble and research materials and parts," said Medland.

But even for Back Market, access to spare parts can be a problem. "We want to know where the good [third-party] parts are, because it can't always be OEM parts. We're sharing that knowledge with our sellers, giving them a reason to be with Back Market rather than an 'everything' shop like Amazon and eBay."

Medland is keen to educate potential buyers on why refurb is important. "The UK produces two million tons of e-waste every year, but in terms of global carbon emissions, 2% comes from the production of electronic devices," she said. "We can prolong the life of these devices. We're also trying to move into repair which, in a way, is detrimental to us because if you're repairing, you're not buying, but that's still a preference."

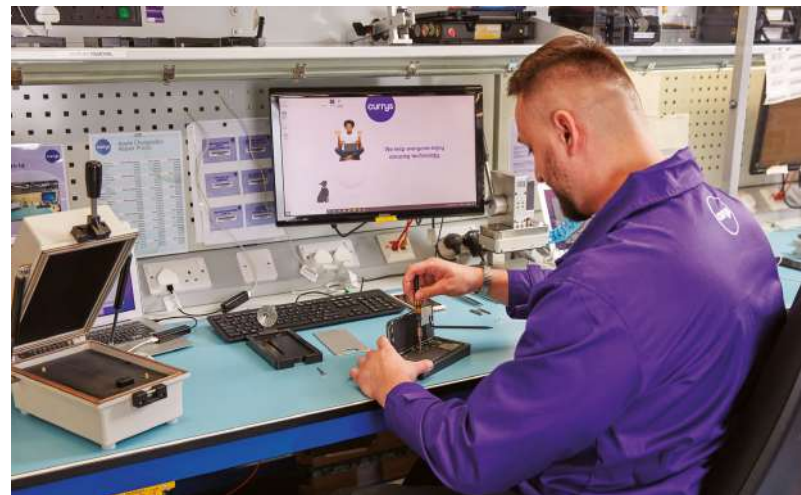
The company recently introduced a trade-in scheme to ensure that usable devices can return to the refurb space and is trialling circularity solutions in France. "Our focus is to get a blueprint so we've got that whole circularity element looked after, to stop devices ending up in recycling," said Medland. "It's a very important programme with very complex solutions."

Forming the circle

The burgeoning market for refurbished equipment is a good thing. Less waste, less cost for consumers, less need to create new devices. But it's not the complete solution and is a long way from a truly circular economy that sees unwanted products harvested as much as possible for re-use, before being recycled as a last resort. "We have to move from a linear economy," said Megan O'Byrne, a PhD researcher

at Cardiff University specialising in the Circular Economy. "Currently, we take resources, make products, then

Our refurbished products have the same warranty as new, so no risk



ABOVE Currys harvests parts from over 5,000 products a week

waste them and we've lost sense that products and resources are finite."

This circularity of resources is key to sustainability. However, professor of materials and society at UCL Mark Miodownik knows precisely why electronics are currently incompatible with a circular economy. "If you put a device in a recycling facility, we don't have the technology to turn it into materials that will become a new device. There are exceptions like gold, but pretty much everything else will be exported or burnt."

Our inability to recapture elements is compounded by the energy spent to acquire them. "Of the known elements in the universe, 50% of them

Are there risks to buying refurb?

If you buy a new product and it goes wrong soon after you get it out of the box, you'd send it back to the retailer. But what about refurb equipment? Does it carry the same level of consumer protection?

We sought the advice of Lisa Barber, editor of *Which? Computing*. "Whether you buy online or from a physical shop, you're protected by the Consumer Rights Act in the event that the product is faulty. You have a legal right to reject goods that are of unsatisfactory quality, unfit for purpose or not as described, and get a full refund – as long as you do it within 30 days from the date you take ownership.

"Between 30 days and six months, you must give the retailer one opportunity to repair or replace it (the retailer gets to choose) before you can claim your refund. Purchasing from an online retailer gives you extra rights from the Consumer Contracts Regulations, so you can change your mind for any reason and cancel the order within 14 days from the day you receive the product. You may have to pay postage, though. This only applies to businesses in the UK, so do check before you buy, particularly if you're buying from an online marketplace."

Barber also offers some words of warning. "Buying from a private seller, whether online or not, leaves you less protected. The manufacturer warranty may still apply, but you will not receive protection from the Consumer Contracts Regulations or Consumer Rights Act 2015, so it's very much 'buyer beware'."

To bolster confidence, the British Standards Institution (BSI) has introduced Kitemarks for Reconditioners and Remanufacturers. Shahm Barhom, BSI product certification director, believes the standard should reassure buyers. "We give confidence to consumers and organisations alike. Manufacturers can offer consumers high-quality products at a lower cost, backed by the Kitemark they can trust."

are in your phone," said Miodownik. "Each comes from a mine and sometimes it's 100 tons to get one ton out, using water, energy and diesel to ship them across the world."

The further tech advances, the harder the problem is to solve. "On a phone's screen, there's a layer ten atoms thick, smaller than a millionth of a hair but vital for it to work," said Miodownik. "At the end of the phone's life, we need those atoms back again. It's an economic problem, a logistical problem but also a science problem."

Sarah Ottaway, sustainability and social value lead at SUEZ, knows what is required to improve tech recycling: legislation. "WEEE regulations have stimulated investment, but recycling technology has a long way to go."

Ottaway's message to *PC Pro* readers is to ensure that we dispose of waste electricals correctly. "If someone's chucked an iPad into their bin or the wrong container at a recycling centre, then legally we cannot retrieve it. In terms of precious metals alone, there are recyclers that can deal with that iPad, but not if it ends up in your bin."

Miodownik estimates it could take two decades before our devices begin to be circular, but refurb is not a fool's errand. There are positive societal bonuses that bring huge value to communities in tangible ways. "There's a whole set of people who are digitally excluded, and refurb is useful to get very good devices get into people's hands," he said.

Ottaway agrees, revealing what SUEZ has learned from Manchester's Renew Hub. "Reuse will need skills and knowledge to grow to the scale that it needs to be. We're opening people's eyes, making them aware of the fantastic jobs out there. That's our vision in the future, a localised industrial economy that's an exciting



ABOVE The Renew Hub in Manchester is the UK's largest re-use facility

space and everyone's clamouring to get a job in the sector."

O'Byrne's research also highlights the positive local effects of refurbishment. "Refurb is for social reasons, like engaging in repair collectives as part of the community," she said. "The changing social background of what we think of refurbishment means that people won't think of it as a last resort, but a conscious decision for good reasons."

The societal impact of refurb is embodied by Christine McCartney, co-founder of Repair Cafe Belfast, who has supported the growth of ten community projects. "A repair cafe is

Repair Cafes are the spaces for skills to come out of the woodwork



LEFT Many devices are unusable because of software and bureaucracy, rather than a physical fault

a place where people feel comfortable, opening them to how a community can find solutions and do stuff itself," she said. "We don't need to wait for government policy or funding, those things are necessary to tackle the circular economy, but we can do stuff now. I'm plugged into a community and, between us, we know how to do a heck of a lot of things."

And there might even be a hands-on role for the tinkerers among the *PC Pro* readership in the refurb movement. "Skills are there but we can't see them because they're in garden sheds and at kitchen tables," said McCartney. "[There are] skills people have gained through their jobs, interests and tinkering. People think we've don't have these skills any more, but we do and Repair Cafes are the spaces for skills and talents to come out of the woodwork." ●

Don't bury your head

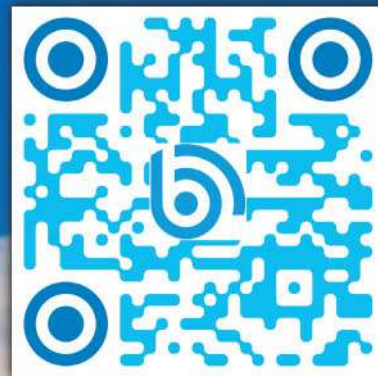
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HOW DO YOU KNOW IF YOU'VE BEEN HACKED?

Don't let attackers sneak under your radar:

Nik Rawlinson reveals the telltale signs

to look out for

Cyberattacks don't look like you might expect – and they certainly don't look like they do in the movies. If your security is compromised, you probably won't see a big flashing sign saying “YOU HAVE BEEN HACKED”, or weird skull-and-crossbones graphics filling your display.

On the contrary, modern attacks lay low. The era when hackers just wanted to attract attention and cause chaos is long past: today, they more likely want to use your computer for mining cryptocurrency, or as a staging point for launching anonymous attacks on remote targets. Or, of course, they may intend to quietly encrypt your personal files, with a view to demanding a ransom for the decryption key. Whatever the goal, it's in their interest to be as discreet as possible, and not to tip you off that you've been compromised, at least until their dirty work is done.

Those scenarios apply equally in business environments, along with the additional concern of digital espionage. For a company, the first indication of an intrusion might look like nothing more than a strange coincidence – a rival beating you to market with a product that looks a lot like your own, perhaps, or pursuing contacts and deals in a way that stymies your commercial strategy. It could be sheer bad luck,

or it could be that someone has been spying on your confidential plans.

Whatever their intention, attackers know to bide their time, quietly siphoning off your resources or learning about your business. According to figures from Sophos, the average “dwell time” – the time an attacker had access to compromised systems before being discovered – was eight days in 2023. That's an improvement on the average of ten days in 2022 and 15 days in 2021, but it's still an alarming statistic. Here are some recommendations that can help you identify and resolve attacks quickly – and prevent them happening in the first place.

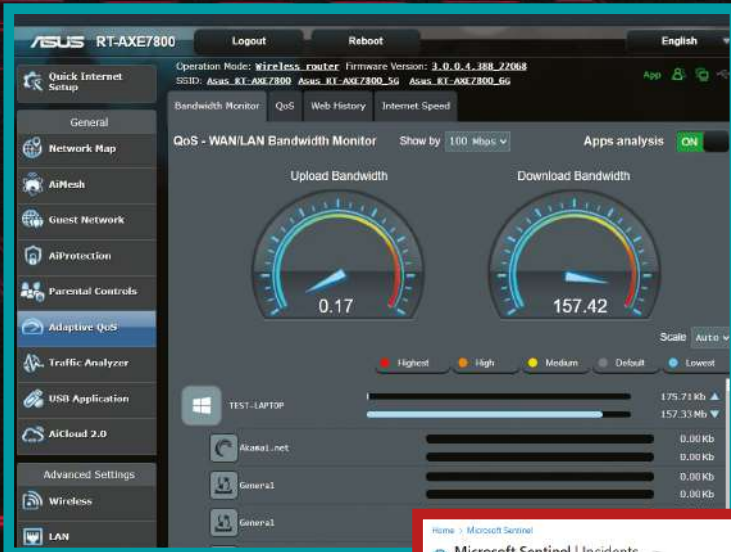
Common threat vectors

Computer security is an area where prevention is certainly better than cure. Many hack attacks are enabled by weak passwords, compromised credentials, brute-force attacks or misconfigured network hardware, so it goes without saying that you should take steps to close off all of these

avenues. In business, each of these potential vectors of attack will already be on an administrator's watchlist, and companies should be enforcing policies to ensure effective credential hygiene. If you're working from home, or just using your own computer for everyday internet duties, you'll need to take matters into your own hands.

To sharpen up your passwords, note that length can be more effective than complexity. Common “complications” such as using digits in place of letters are well understood, and brute-force attacks will breeze through them. However, each additional character in your password significantly increases the length of time it will take to crack. The usual advice about not recycling passwords or using personally identifiable information still applies.

Remember, too, that no matter how strong your passwords are, they could be exposed by an attack on the services you use them to log into. Alternatively, you could be tricked into revealing them by phishing attacks or other types of social engineering. These are even bigger concerns for businesses, as the consequences of a malicious actor gaining access to company resources could be enormous.



IT'S IMPORTANT TO ENSURE THAT ALL DEVICES ON YOUR NETWORK ARE KEPT PATCHED AND UPDATED

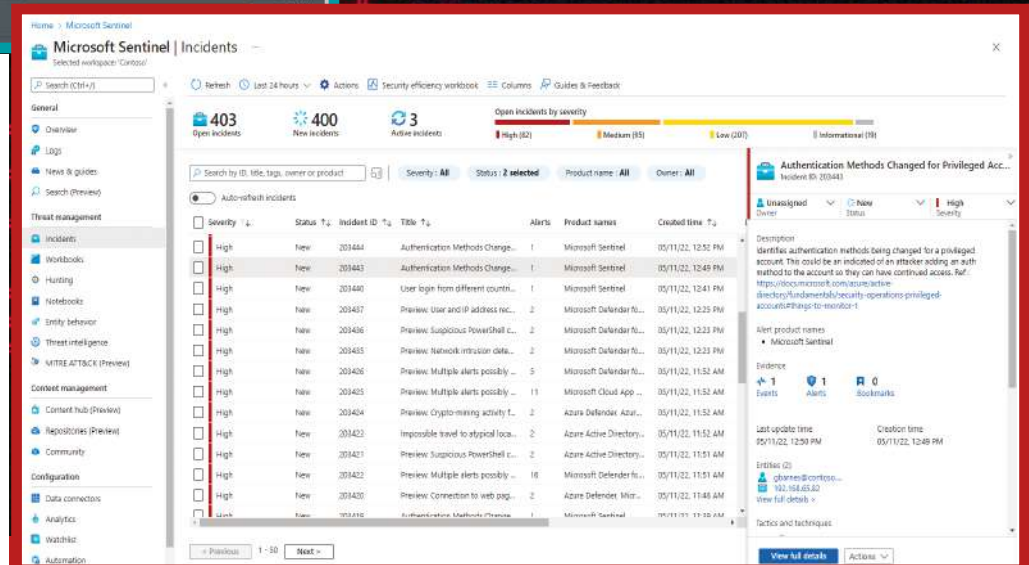
LEFT Most routers feature a bandwidth monitor so you can see if there has been any unusual network activity

BELOW Microsoft Sentinel analyses data from a wide range of sources to identify potential security incidents

To reduce the risk, 2FA and biometrics make it harder for untrusted outsiders to get into your systems. It's also an established rule of IT administration that users (and services) should only have access to the resources and privileges they need. This way, if someone successfully steals a username and password, there's a limit to how much damage they can do. You can apply that principle to your home network, as well as in the office.

This approach also helps against another danger in the workplace: insider threats, such as when a member of staff illicitly takes copies of sensitive data that can be used for competition or extortion. You might imagine that such attacks are rare, but they're a growing problem. Analyst Proofpoint reports that in 2022 the cost to business of insider security threats increased by 62% in retail organisations, and by 47% in financial services. Response times, meanwhile, are slipping: it now takes 85 days to contain an insider threat, compared to an average of 77 days just two years ago. Managers can minimise the risk of such attacks with a coordinated approach across teams and departments, ensuring workers know how to spot and report suspicious behaviour or security loopholes.

Whether you're managing a personal Wi-Fi router or a huge corporate LAN, it's also important to ensure that all devices on your network are kept appropriately patched and updated. A report from Tenable Research revealed that, of the five most widespread cyberattacks in 2022, four relied on "zero-day" exploits which were patched on the same date as they were first observed in the wild (see tinyurl.com/356research). In other words, most infections



could have been avoided if individuals and IT managers had kept their protection up to date.

Another practical measure you can take is to enable MAC address filtering on your router, to ensure that only known devices can connect to your network. This doesn't give you perfect protection, as addresses can be spoofed and bypassed, but it will almost certainly keep casual interlopers from connecting to your network. Similarly, it's a good idea to disable remote management on your router, so that settings can only be changed from inside your network.

SIEM and SOAR

Even if you religiously follow best-practice security measures, your network could be compromised via means outside of your control. That's why it's important to recognise an intrusion as soon as possible, so you can neutralise it – hopefully – before it's able to do any damage.

For home users, the signs of a compromise can be subtle. You may notice a change in the performance of

your computer or network, or requesters that you haven't seen before (see "Has my home been hacked?", overleaf). Businesses can spot problems via network monitoring; the catch here is that a fleet of tens or hundreds of computers will generate a lot of data, far more than an in-house security team can possibly analyse by hand. This is where SIEM, SEM and SOAR tools come in.

SIEM stands for Security Information Management, and refers to the long-term process of collecting usage data for analysis. This data then feeds into SEM – Security Event Management – which identifies patterns within the data. Combined, these two approaches become SIEM – Security Information and Event Management – which encompasses an overarching workflow of gathering, analysing and acting upon data.

As the US National Institute of Standards and Technology explains, SIEM "provides the ability to gather security data from information system components and present that



HAS MY HOME BEEN HACKED?

For a home network, advanced measures such as SIEM, SOAR and UEBA aren't practical, but there are some red flags you can look out for as indications that you may have been compromised.

1 Suddenly sluggish performance

This can be caused by something unaccounted-for eating up your computer's resources. A continually running fan, a laptop that gets unusually hot or a battery that conks out in double-quick time can all also be clues that a rogue process is working the processor hard.

2 An unusual spike in network traffic

This is another sign that something is amiss; it could be caused by someone exfiltrating your data, using your internet link to fire off spam or initiating a flood of connections for a DDoS attack. If you have a fast internet service you might not notice an unusual load, but many routers include traffic monitoring and management features that can help.

3 Non-functioning passwords

When hackers gain access to an online service or router, the first thing they'll often do is change the password, to prevent you from checking up on their activity and kicking them out. If you find you're unexpectedly locked out of an account, take action sooner rather than later.

4 Odd pop-ups

We said that modern infections like to lie low, but there's a particular species of malware that does the opposite, throwing up alarms and alerts that typically warn you of computer issues or (ironically enough) a virus infection. You'll then be urged to buy a particular piece of software or visit a website to "fix the problem" – needless to say, it's a scam.

5 Unexpected search results or web content

A router hack or a devious piece of malware can hijack your traffic, sending you to unfamiliar sites, or bogus phishing copies of legitimate ones. You could easily be tricked into entering personal or business-critical information, such as webmail or cloud login details. These sites can also install further malware on your machine.

In all cases, if you think you might have been breached you should follow the usual security procedures. Ensure the OS, applications and firmware are up to date on all your devices; perform a thorough antivirus scan; check system and network settings; and change any passwords that might have been compromised.

ENSURE YOU KNOW HOW STAFF CAN CONTINUE WORKING IF YOU NEED TO DEAL WITH AN INTRUSION

data as actionable information via a single interface". An effective SIEM solution can spot the signs of an intrusion or malicious interference far more quickly than a human could.

Finally, we come to SOAR – Security Orchestration, Automation and Response. This is the component that actively responds to intelligence from the SIEM layer and other inputs such as IoT alerts and regular security scans. That might mean blocking certain types of access, or locking down particular resources. SOAR workflows are generally defined in advance, so security teams will need to remain vigilant, pay attention to the output of their SIEM tools, and define the workflows that SOAR should take in response. Once set up, these workflows are ready for immediate use should a threat arise, reducing dwell time and minimising risk to a company's data, systems and reputation.

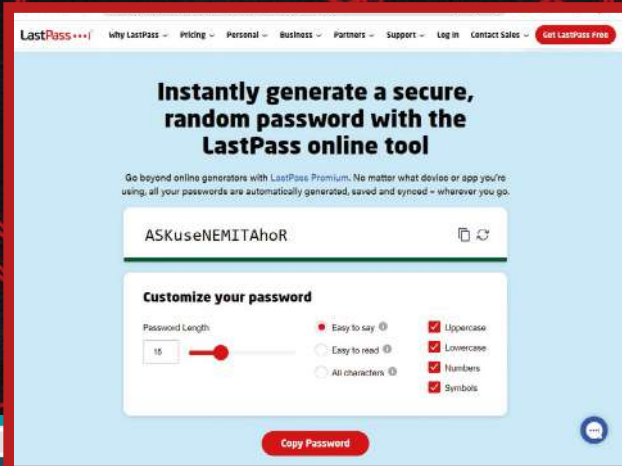
SIEM and SOAR systems are increasingly making use of machine learning to identify hidden patterns within big data. This is particularly relevant in the case of one last acronym: UEBA, or User and Entity Behaviour Analytics, which works by monitoring actual activity and spotting when a user, a server or any sort of network device starts doing something out of the ordinary. As IBM describes it, UEBA "is effective at identifying insider threats – malicious insiders or hackers who use compromised insider credentials – that can elude other security tools because they mimic authorised network traffic" (see tinyurl.com/356ibm).

Devise a plan of response

Once an intrusion is detected, time is of the essence – so whether you're working with a single personal computer or a whole office full of devices, it's best to plan out possible scenarios and responses in advance. In fact, being prepared is potentially more important for home workers,

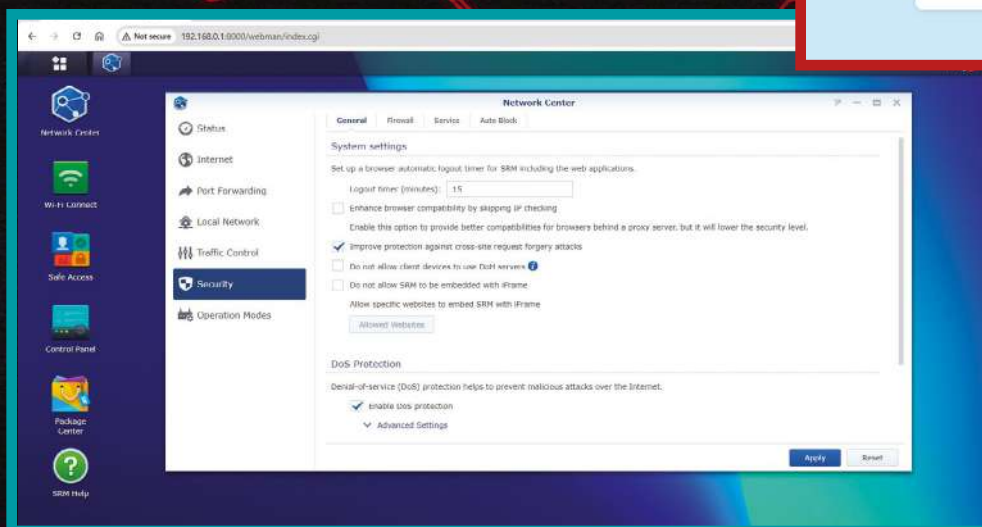


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ABOVE When it comes to passwords, length can be more effective than complexity

LEFT Synology's Network Center provides an easy-to-use way of monitoring status and resource usage



who typically don't have specialist IT support staff on hand, nor conveniences such as backup archives and spare known-good hardware. Think about how you'd stay safe and productive if an attack made your main computer unusable, or if the files stored on it were leaked or encrypted.

Businesses should start by drawing up a comprehensive list of network assets, both on site and remote. Ensure you know how staff can continue working if you need to take steps to deal with an intrusion – or determine whether your best hope of a swift and sure recovery is to temporarily shut down all access and swallow any losses. Don't forget staff who might be working remotely and need to connect to corporate systems. Consider using a central management database to tally users and issued equipment.

As well as figuring out what you need to do, make sure everything is documented. Writing up technical manifests and hypothetical scenarios may feel like a chore when everything's running smoothly, but in an emergency you'll be glad to have a record of your network infrastructure. If you've offloaded your services to a third-party cloud

provider, ensure you have network maps of your remote processes, and that you understand how your data is looked after. If an infiltration results in data being lost or leaked, you may be accountable: being able to show that you've taken all reasonable measures to secure your network and data assets won't entirely mitigate the situation, but it will reassure users, clients and the authorities by demonstrating your commitment to security and the responsible handling of third-party data.

The penalties for poor caretaking of personal data have become more significant over recent years – while at the same time, threats are constantly evolving. Whatever scale you're working on, therefore, you need to stay abreast of changes in the security landscape. This inevitably involves a cost, be it in terms of research or financial investment, but it will be far lower than the cost of a breach, which could involve the loss of irreplaceable data, disruption to your business and the unquantifiable value of a dented reputation. ●

NETWORK SAFETY FOR BUSINESSES

For companies seeking professional SIEM and SOAR solutions, Microsoft Sentinel is a cloud-based service that can draw in metrics from a wide range of products published by Microsoft and others. It analyses all of this data to identify "incidents", which are multiple instances of matching alerts; this helps deliver a meaningful and manageable overview of what's happening within the IT estate. After all, a series of disconnected alerts might not mean much if they appear now and then, but when collected together they can highlight the presence of a threat or network issue. Sentinel isn't limited to Windows either: data sources can include API output, or logs generated by machines running Linux. Find out more at tinyurl.com/356sentinel.

Another option is Sumo Logic's Cloud SIEM (sumologic.com), which uses what it calls a signal-clustering algorithm to automatically group related signals. When a set threshold is reached (by default within a 14-day window) it generates an "Insight", on the basis of which admins can start investigating. Datadog (datadoghq.com) likewise combines alerts using what it calls composite monitors to minimise alert noise. The ability to spot patterns in data more effectively than human operators, and track them over the longer term, can expose telling deviations from the norm that would otherwise be easy to miss.



Use your Raspberry Pi as a home VPN

Easily access your home files,
and access the internet
securely from anywhere.

Darien Graham-Smith explores
the free PiVPN tool, which
turns any Raspberry Pi into a
fully featured VPN server

Back in issue 336 we showed you how to configure a Raspberry Pi as a VPN gateway for your home network, routing all your internet traffic through a secure, external VPN server.

But what if you want to do the opposite? Running a VPN server on your local network enables you to securely access home devices such as NAS appliances and printers from anywhere in the world. You can also route your internet activity through your home ISP connection when you're travelling – handy for getting around local access restrictions, or if you're using an untrusted Wi-Fi service and want to ensure the operator can't spy on your activity.

A VPN server can be hosted on almost any computer, and inbound VPN capabilities are also built in to some routers. However, as in so many scenarios, the Raspberry Pi makes an excellent choice of platform as it's very cheap to acquire and run, yet powerful enough to support advanced features and configurations that aren't normally available on router-based VPNs. That applies even if you're using the most lightweight board: the PiVPN system we'll discuss below will run happily on any model, including the Zero, as long as it runs Raspberry Pi OS.

Introducing PiVPN

PiVPN (pivpn.io) is a free package that automatically installs and configures VPN server software on your Raspberry Pi. To be clear, it's not a VPN server itself, but rather a friendly installer and manager for the open-source OpenVPN and WireGuard VPN server components. If you're a Linux enthusiast you could install and configure those core packages yourself, but there's not much reason why you'd need to, except to gain experience: PiVPN is a quicker and easier way of reaching the same goal.

The publisher officially recommends deploying PiVPN on a board that's running the latest version of Raspberry Pi OS Lite, but that's just for the sake of efficiency; there's no need to use the full version of the OS if you're going to dedicate your Pi solely to server duties. However, if you want to add PiVPN to a machine that's already running Raspberry Pi OS, that's no problem. You can also use it on other Debian-based Linux distributions, such as Ubuntu.

Initial installation

Installing PiVPN is as easy as entering a single command at the Raspberry Pi Terminal app, or into an SSH session. And that command is:

curl -L https://install.pivpn.io | bash

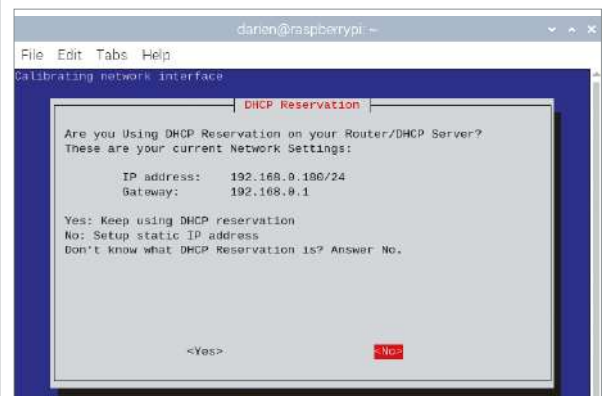
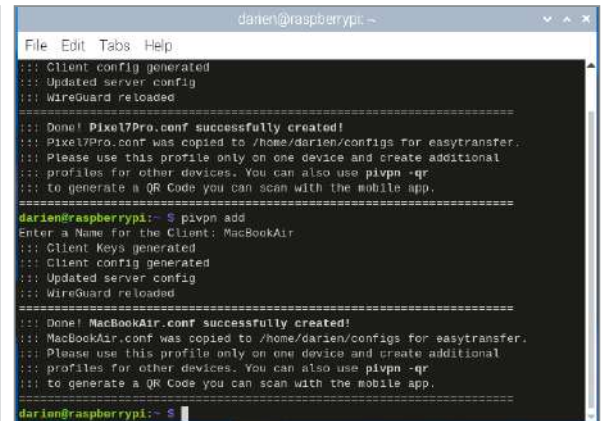
This tells the Pi to fetch the latest setup script from the PiVPN website and run it (by piping the commands one by one through the bash command shell).

While this installation method is gloriously simple, it does entail a theoretical security risk: the curl command fetches and runs remote instructions without giving you a chance to review them, so if a hacker were to hijack the site and upload their own malicious script in place of the legitimate installer, the consequences could be disastrous. Before installing, we recommend you check the main pivpn.io site, and search around the web, to ensure there are no reports of PiVPN being compromised. If you're au fait with Linux scripts you can also visit install.pivpn.io with your browser to see exactly what commands will be executed.

Configuring PiVPN

Once the PiVPN installer has downloaded the basic setup components, you'll see a pseudo-graphical interface welcoming you to PiVPN. Simply hit Return to begin the configuration.

Setup begins with a notice that your Pi needs a static IP address on your home network; this is so your router always knows where to direct incoming VPN connections. If you're



TOP Once PiVPN is running, you need to create client profiles for the VPN

ABOVE The wizard asks if you're using DHCP address reservation on your router

not using IPv6 routing on your home network, the next page of the setup wizard will offer to force all IPv6 connections through the VPN server; this is normally a good idea, as it protects the privacy of your originating client, so leave the default option selected ("<Yes>") and hit Return again.

Next, the setup wizard will ask if you're using DHCP address reservation on your router. If you know what this means, and have already set it up for the Raspberry Pi, then you can use Tab or the cursor keys to select ("<Yes>") and hit Return. If it's something you still need to do

then this is the ideal time to hop over to your router's administration page or app and reserve your Pi's IP address. It doesn't matter what the actual address is, as long it's the same every time the board connects to the network.

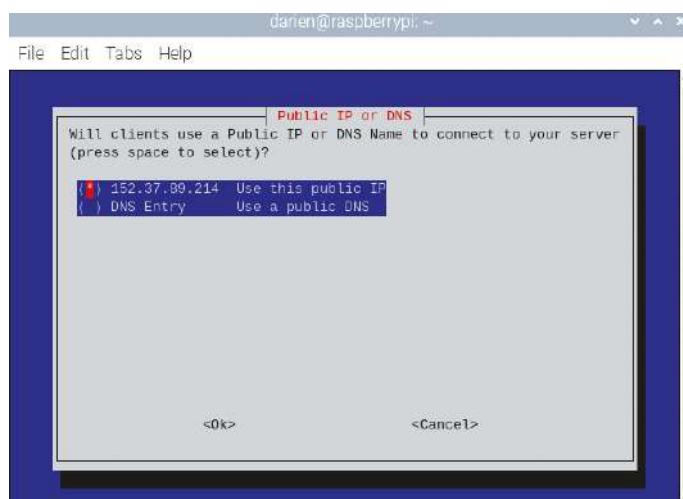
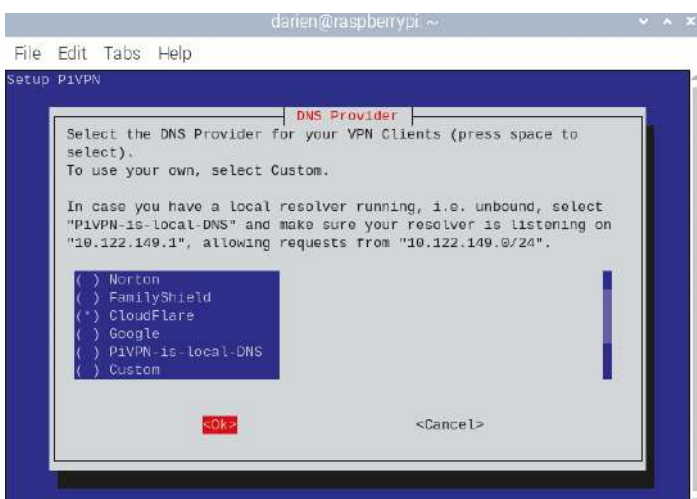
Alternatively, you may prefer to select "<No>" and use your Pi with a static IPv4 address, but if you're going to do this you need to ensure the address the Pi sets for itself doesn't clash with one handed out by

Setting up WireGuard with a QR code

If you're using a phone or tablet with a camera, you can set up the WireGuard client app by scanning a QR code directly from the Raspberry Pi. To do this, enter **pivpn -qr -a256** into a Terminal window; this will prompt you to pick a VPN profile, then generate a code for it on the screen. If the code is too big to fit in the window, maximise the window, then press **Shift+Ctrl+-** a few times to shrink down the contents. Finally, in the WireGuard app, tap to add a new profile, then tap "Scan from QR code" and simply point your camera at the screen to import your settings.



The Raspberry Pi makes an excellent choice of platform as it's very cheap to acquire and run, yet powerful enough to support advanced features



your router to a different device. You can check your router's DHCP address range from its management console, and optionally adjust it to fit – for example, my Pi is using 192.168.0.180, so I might set my address range to run from 192.168.0.2 to 192.168.0.179. Alternatively, you can change the Pi's address to something outside of your router's DHCP range – so if the range goes up to 192.168.0.250, you could configure the Pi to use 192.168.0.251.

VPN configurations

Once you've pinned down your IPv4 address, the PiVPN installer will ask which local user account will store your VPN configurations. If you've set up your Pi in the normal way the only option will be your personal account, but you might prefer to create a user called (for example) "pivpn" who looks after VPN configuration files – this means you can freely administer other accounts without having to worry about accidentally messing up your VPN settings.

Now you'll be asked whether to use the WireGuard or OpenVPN protocol for your VPN server. WireGuard is the default, and for good reason – it's faster and more energy-efficient. This is one of the big benefits of PiVPN over router-based VPN systems, as those are usually limited to OpenVPN. However, if you prefer to use OpenVPN for any reason, it still works perfectly well – see "Using OpenVPN", opposite.

Once you've selected your protocol, the PiVPN installer will download the necessary components, and prompt you to pick a port. The default should be fine – 51820 for WireGuard – but if you later find you can't connect from outside of your network, you can try changing your VPN port to a different number. If you still can't connect, see "Adventures in port forwarding", right.

Next we come to DNS settings. When using a VPN, you don't want the untrusted remote network provider to handle your DNS requests, as that will let them see which sites you're

connecting to (and potentially block your access). Instead, therefore, PiVPN prompts you to choose a third-party service that will be accessed via the VPN. It doesn't normally make any difference which provider you pick: choose whichever one you like, using the cursor keys and Space to select. If you're an advanced user you can scroll down

ABOVE LEFT PiVPN prompts you to choose a third-party DNS

ABOVE It will also ask if you'll use a public IP address or a DNS name

and choose to use your Pi as its own DNS resolver, or configure some other custom configuration. When you've made your selection, hit Tab to select "<Ok>", then hit Return.

PiVPN will then ask whether you're going to use a public IP address or a DNS name to access your VPN. If you're using a dynamic DNS service such as **no-ip.com** or **DuckDNS.org** to simplify remote access to your router then you can select this option and enter your registered domain name at the next page. Otherwise you can just use your router's external IP address, which will be shown on the page. This might be a convenient time to make a note of it; you can normally also find it in your router's management console, or by visiting a third-party website such as **myexternalip.com** from any computer inside your home network.

To finish up, the PiVPN installer will now quickly generate your cryptographic keys, which will be used to confirm your identity when you connect. As a further security measure, you'll be prompted to enable unattended updates, to ensure your Pi's defences are kept up to date. However, as the installer warns, some updates will require a reboot to take effect; you might consider setting it to automatically reboot every night, by editing the crontab file. We'll let you figure out the specifics of that.

You've now set up the PiVPN server. Hit Return to acknowledge the information page, then select "<Yes>" to reboot the Pi, just to ensure everything is running as it should.

Profiles and routing

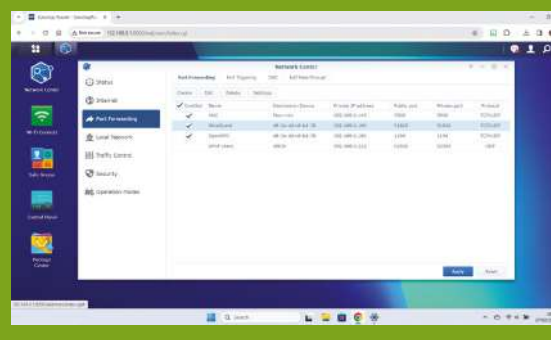
Now that PiVPN is running, you need to create client profiles for your VPN – configuration files that contain the network addresses, settings and credentials that your devices will use when connecting. You should create a separate profile for each client device you want to connect from, so that PiVPN can confirm the identity of your different hardware devices. In my case I've created

Adventures in port forwarding

Setting up port forwarding ought to be simple, but different routers handle it in different ways – and sometimes even when you think you've got everything set correctly, the connection times out when you try to access your Pi (or some other endpoint) from outside your home network.

This can happen if you have a firewall or other network security feature activated – either on the router or on the Pi itself – which hasn't been updated to allow your new forwarding rules. You may be able to get things working by putting the Pi into the router's "DMZ", which means any unrecognised traffic will be forwarded to it. Needless to say, though, this can raise security issues.

Another possibility is that your ISP is using CGNAT (carrier-grade network address translation). As with the regular NAT technology used on your home network, this means that your external IP address is shared among multiple subscribers, and custom port forwarding rules configured at your router won't work because connections on those ports aren't being forwarded to you by the upstream NAT gateway. There are technical ways around this, but by far the easiest and most reliable is to pay a little extra for your own static external IP address, assuming the ISP offers this service.

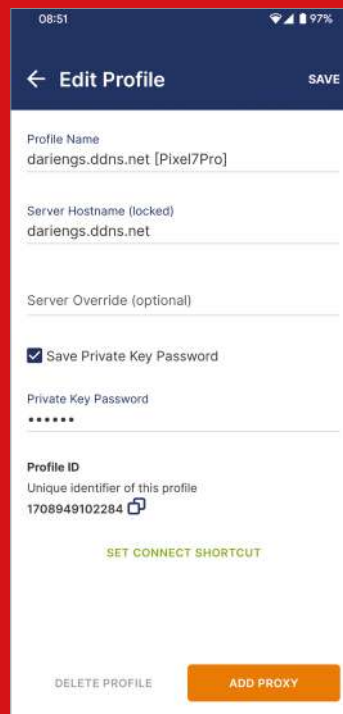


Using OpenVPN

If you want to configure PiVPN to use OpenVPN rather than WireGuard, the setup process is almost identical. However, as we've noted, the port you need to forward is different – it's 1194 for both TCP and UDP connections – and when you create your connection profiles you'll also need to set a password for each one, as OpenVPN doesn't use cryptography keys in the same way as WireGuard.

OpenVPN also uses its own client app, which you can download for all major platforms from openvpn.net/client. It works in much the same way as the WireGuard app, but it doesn't support QR code scanning, so you'll need to copy across the relevant configuration files from `/home/[your username]/ovpns` on your Raspberry Pi.

PiVPN doesn't require you to choose between WireGuard and OpenVPN – you can run both servers side by side. To set this up, just run the PiVPN installer twice, choosing one VPN platform the first time and the other the second. Once both VPN servers are up and running, you can control them using the familiar `pivpn` command, followed by either `wg` or `ovpn` before your arguments, so `pivpn wg -c` will show the status of your WireGuard clients, while `pivpn ovpn -c` will present the same information for OpenVPN.



[username]/configs, and there are several easy ways to get it from there onto the client device, such as using Google Drive or email. Alternatively, you may be able to provide the settings via a QR code (see p45). Once you've imported your profile, all you need to do is name your tunnel and you're ready to go.

To use your new VPN connection, just activate it in the client. The encryption key confirms your identity, so you don't need to provide a username or password. Be aware that this means you need to keep your client device secure, as anyone who gets into it could get access to your home network.

Once connected, you should be able to use the internet as before – but if you check your external IP address you should now see that it's changed, along with your virtual location. If you're using a desktop or laptop computer you should also be able to browse the local network and see your other computers, printers, storage devices and so forth.

You can check the status of your PiVPN connections by entering `pivpn -c` on the Raspberry Pi – this shows all registered clients, along with the last IP address they connected from, their virtual IP address, details of bytes exchanged and the last time they connected. If you want to change your configuration, enter the same `curl` command as you used for the original installation; this time it will detect an existing installation and give you the option to update, repair or reconfigure your settings. And if you ever want to remove PiVPN from your Pi, just enter `pivpn -u` to completely uninstall it. Enter `pivpn` on its own to view other valid commands. ●

two profiles, called Pixel7Pro and MacBookAir – you get the idea.

If you haven't already, you'll also need to set up port forwarding on your router, so that incoming connections on the specified port are directed to your PiVPN server. The precise steps for doing this will depend on the make and model of your router, but it should be simple to do. In my case, for my WireGuard server, I simply needed to specify UDP port 51820, and set the IP address of my Pi as configured or confirmed earlier. If you're using OpenVPN, choose port 1194 for both TCP and UDP protocols.

Client connections

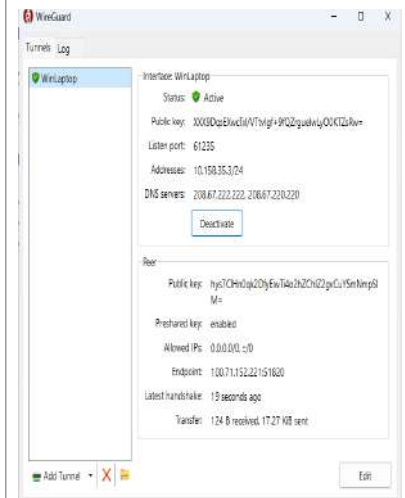
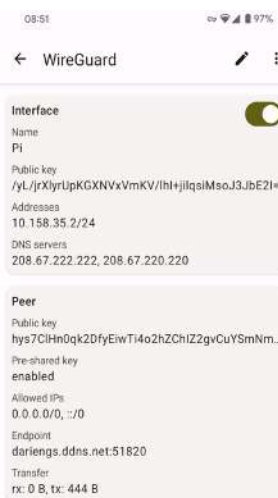
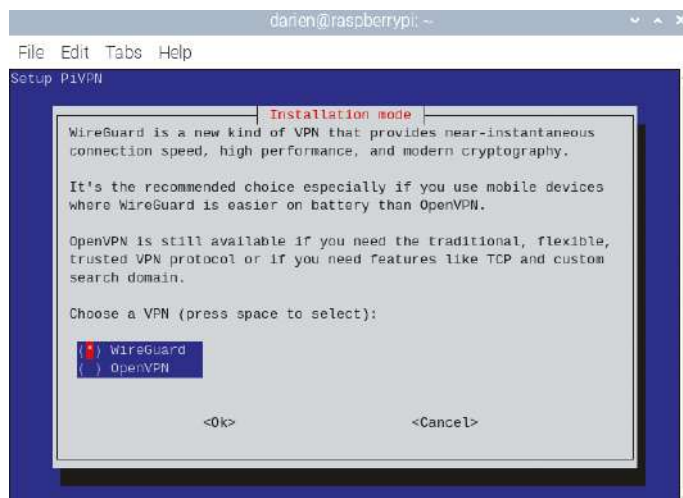
To access your WireGuard VPN you'll need to install the free WireGuard client on the connecting device. Installers for Windows, macOS, Android, iOS and a whole range of Linux-type platforms can be downloaded from wireguard.com/install.

Once you've got the software installed and running, hit the button to "Add a new tunnel" (this is what WireGuard calls VPN connections). You'll now be prompted to import the relevant VPN profile; you'll find a copy of it on your Pi in `/home/`

BELOW LEFT You'll be asked whether you want to use the WireGuard or OpenVPN protocol

BELOW The free WireGuard client is available for Android devices...

BELOW RIGHT ...as well as Windows, and other platforms such as iOS, macOS and Linux



You need to keep your client device secure, as anyone who gets into it could get access to your home network

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Dell XPS 14 (2024)

The 14.5in OLED display and Core Ultra power are the stars, but the minimalist design will split opinions



SCORE ★★★★★

PRICE As reviewed, £2,333 (£2,799 inc VAT) from dell.co.uk

For better or for worse, the new Dell XPS 14 follows the same design language as the XPS 13 Plus (see issue 350, p52). That means the same LED function row and invisible touchpad that made the XPS Plus such a divisive product.

Less divisive is the inclusion of Intel's Core Ultra chips, which pack a neural processing unit (NPU) to accelerate AI-driven tasks. As we cover in this month's feature (see

p28), the NPU remains a jam-tomorrow technology for the most part, but the XPS 14's AI capabilities could bear fruit once more apps begin making the most of it.

Whether you care about AI or not, the Dell XPS 14 still has plenty going for it. It's compact and light enough to be considered an ultraportable, while the colourful 14.5in OLED display is perfect for work and entertainment. Plus, thanks to the optional Nvidia GeForce RTX 4050 GPU, it can play the best PC games on modest settings.

■ Business focus

Dell sent us a business model of the XPS 14, which uses a Core Ultra 7 165H chip rather than the Ultra 7 155H you'll find on Dell's website. There's little difference between the chips other than the 165H having a higher 5GHz peak frequency (4.8GHz for the 155H) and support for Intel vPro Enterprise rather than vPro Essentials.

Our review system also included 32GB of RAM, a 2TB SSD, GeForce RTX 4050 graphics and the top-end

ABOVE With Intel's Core Ultra chips inside, the XPS 14 is well equipped for AI tasks

"I like the look of the buttons above the keys – it's not something you often see on laptops – but is it actually useful? Not in my view"

BELOW The sleek-looking body is sturdily built

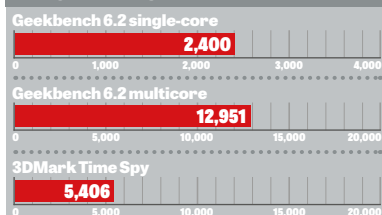
OLED panel, which is why the quoted price is close to the three grand mark. Stick to the base system and the price drops to £1,599, which includes 16GB of RAM, a 512GB SSD, Intel's Arc

graphics and an IPS panel with a modest 1,920 x 1,200 resolution. Choosing the 3,200 x 2,000 panel we tested adds £300 to the price.

■ Future article

Let's first address the two most contentious items: the LED function row and the touchpad. Both take some getting used to, particularly the invisible glass touchpad, as the space beneath the keys is completely flat. With no lines denoting where it begins and ends, I initially found myself swiping on the wrong area. Once I adjusted, though, using the smooth and responsive touchpad became second nature. The piezo technology used to provide a clicking sensation is also a nice touch.

BENCHMARKS



BATTERY LIFE



I'm less enamoured with the LED function row. I like the look of the buttons above the keys – it's not something you often see on laptops – but is it actually useful? Not in my view. What's more, having no physical function row put me off my stride when touch-typing: I kept having to look down at the keyboard to find the button I wanted to press. I'm still not used to this, even after many hours of testing.

Dell has at least solved one of the problems that beset the XPS 13 Plus's capacitive function row, which stay alight at all times. On the XPS 14, they turn off after ten seconds of inactivity. A welcome move, since you might not want the bright function row glaring at you the entire time.

Dell's XPS laptops tend to have excellent keyboards, and the new XPS 14 is no exception. Thick keycaps, 1mm travel distance and virtually no spacing between keys make typing on this keyboard both efficient and pleasurable. Even if you have big hands and prefer mechanical keyboards, you won't have any trouble typing on this device.

■ A-list display

The OLED InfiniteEdge touchscreen display is another hit, with vibrant colours and deep blacks. Plus, that sharp 3.5K+ resolution allows you to see even the most minute details. Everything from text on web pages to fast-moving videos looks dazzling on the 120Hz display. Though I mostly used the XPS 14 for work, it's a splendid device for all kinds of after-hours entertainment.

The numbers echo this, almost exactly mirroring the XPS 13 Plus and the M3-toting 14in MacBook Pro (see issue 352, p46). The DCI-P3 coverage hit 80% with an average Delta-E of 0.3, compared to 81% and 0.2 for the XPS 13 Plus (83% and 0.1 for the MacBook). However, Apple's laptop stretched its lead for SDR brightness, reaching a peak of 555cd/m² compared to 380cd/m² on the XPS 14. Dell's laptop hit 600cd/m² in HDR tests, though.

I haven't tested the IPS panel, but previous experience suggests it will have a similar gamut and accuracy to the OLED offering. Dell claims a peak brightness of 500cd/m², while a 120Hz refresh rate is always welcome. However, you'll lose out on sharpness – 1,920 x 1,200 over 14.5in gives a 156ppi pixel density compared to 260ppi for the OLED panel – and it doesn't support touch.



■ Labs results

Our XPS 14 packed an Nvidia GeForce RTX 4050 graphics card, and I found most modern games played at medium settings at 1080p resolution. For example, at those settings, *Doom Eternal*'s frame rate fluctuated between 90 and 105fps. That's not too surprising given that this is one of the most well-optimised titles out there.

For *Cyberpunk 2077*, I had to enable the frame-boosting DLSS option, where the game ran at around 35 to 45fps. That's below the 60fps rates I prefer, but playable nonetheless.

We also ran the machine through our regular benchmarks, including 3DMark Fire Strike (12,338) and Time Spy (5,406). Our games tests used the Highest ratings at 1080p, where *Borderlands 3* returned 17fps, *Shadow of the Tomb Raider* 41fps, *Total War: Warhammer III* 40fps and *Sid Meier's Civilization VI: Gathering Storm* 75fps. Only the latter was playable at the screen's native resolution, with an average of 54fps.

The other benefit of having RTX graphics is that it adds to this laptop's AI toolkit, but as it also adds £450 to the baseline price, you may decide that it's an upgrade too far. The same investment would upgrade you to 32GB of RAM and a 2TB SSD.

Our test unit included both those upgrades, too, and the result was highly impressive speeds. Take the drive, which scorched its way to 4,773MB/sec reads and 5,539MB/sec writes in BlackMagic's tests.

If you buy the XPS 14 with an Ultra 155H processor, it won't quite match the scores we saw – but it won't be far behind, either. And the unit scored strongly, with 2,400 in the single-core section of Geekbench 6.2 and almost 13,000 in the multicore section.

Apple's M3 chips are faster in the single-core test, topping 3,000, but the XPS 14 beats the 12,052 multicore score of the 15in MacBook Air (see p56). This is a fast machine.

■ Retro battery life

Where Apple pulls away is for battery life. Its latest laptops all excel in this area – 15 hours for the latest Air models (see p54) – while the XPS 14 gave up after 6hrs 26mins. We saw a similar result for the XPS 13 Plus.

Nvidia's RTX graphics will be a factor here, and it wouldn't be a shock to see life increasing to almost ten hours with Arc graphics. After all, a 70Wh battery is plenty for a 14in laptop. However, any improvement in battery life is speculation at this stage, and I must judge the XPS 14 on what I've seen. And it isn't great.

Nor is this the lightest laptop, weighing 1.8kg with Nvidia graphics and 1.7kg without. Still, the XPS 14's sleek body meant I had no concerns when travelling with it to the office

or lugging it around at home. Sturdy is the word that springs to mind, whether describing the build quality or the screen hinges. Although I do wish Dell would add a lip to the lid, to make it

easier to open one-handed.

This aside, XPS laptops match the best MacBooks when it comes to eye-pleasing and practical designs; here, you benefit from a microSD card slot to accompany the three USB-C/Thunderbolt 4 ports, for instance. Plus, Dell offers more options with less wallet-gouging upgrade prices.

I'm not a fan of certain aspects of the XPS 14, particularly the capacitive function row and lipless lid. And let's not even talk about battery life. But the XPS 14's gorgeous OLED display, svelte design and RTX-powered speed manage to just outweigh the negatives. **TONY POLANCO**

ABOVE The invisible glass touchpad takes some getting used to

"Everything looks dazzling on the 120Hz display. Though I mostly used the XPS 14 for work, it's a splendid device for all kinds of entertainment"



ABOVE The sharp 3.5K+ resolution allows you to see even the most minute details

BELOW Connections include three USB-C 4 ports and a microSDXC card slot

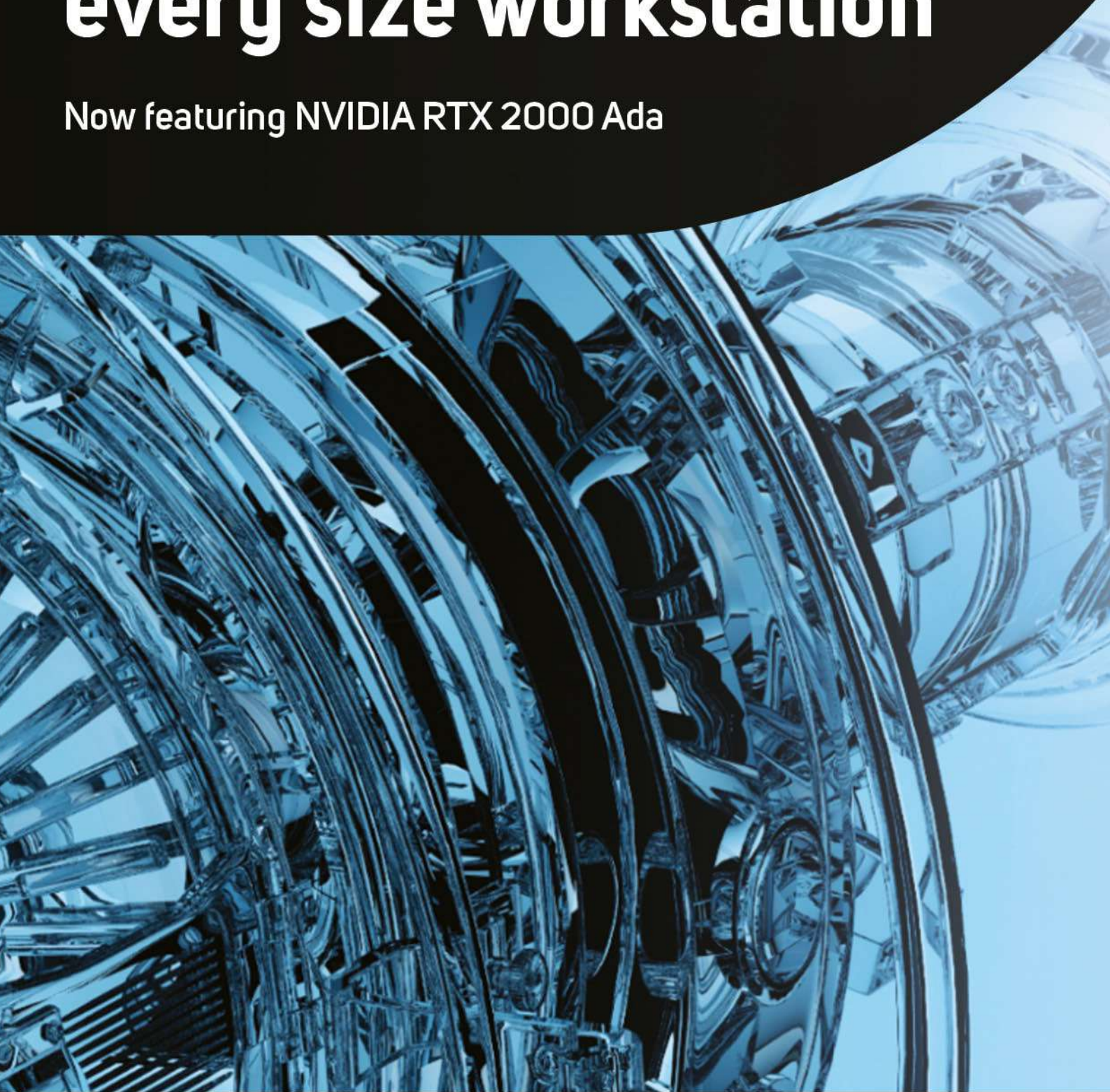
SPECIFICATIONS

16-core (6 P-cores, 8 E-cores, 2 LPE-cores) Intel Core Ultra 7 155H processor • 6GB Nvidia GeForce RTX 4050 graphics • 32GB LPDDR5X-7467 RAM • 14.5in 120Hz OLED touchscreen, 3,200 x 2,000 resolution • 2TB M.2 PCI-E Gen4 SSD • Wi-Fi 6E • Bluetooth 5.3 • 1080p IR webcam • 3x Thunderbolt 4/USB-C 4 • microSDXC card slot • 3.5mm headphone jack • 70Wh battery • Windows 11 Home • 320 x 216 x 6.7-19mm (WDH) • 1.8kg • 1yr Dell Premium warranty

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HP Spectre Fold 17

The neatest execution of the foldable PC concept yet, but wait for the price to tumble before buying

SCORE ★★★★★

PRICE £4,083 (£4,899 inc VAT)
from hp.co.uk

It's true: HP really is expecting people to spend almost five grand on a single computing device. It almost makes the £4,239 that Lenovo demands for the ThinkPad X1 Fold 16 (see issue 355, p58) look reasonable.

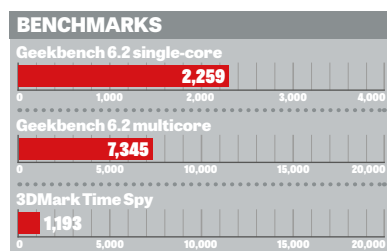
But there are reasons to choose the HP. Of the three foldable PC designs I've tested, HP's is the cleverest. Asus arguably rushed out the Zenbook 17 Fold (see issue 338, p50), which costs £3,299 but comes with bulky padding around the hinge. Lenovo relies on a separate stand to keep the screen upright in all-in-one mode, again adding bulk.

HP's design is the most compact by a distance, with a kick-out stand to keep the screen upright while the keyboard is sandwiched between the folded screen during travel.

■ Laptop flexibility

Initially you might wonder why there's a crease between the trackpad/palmrest area and the keys. That's for a scenario where you only put the top half of the keyboard onto the screen; the rest then folds down. This gives extra vertical pixels to work with, as shown in the photo opposite. Cleverly, Windows Snap still works, so you can snap an active window to the top section and then have a smaller window (or two) beneath.

Cover the whole half of the screen with the keyboard and the HP Spectre looks like any other ultraportable, with a dark, matte blue metal finish giving it a professional air. However, the keyboard



occasionally slips – the magnets could be stronger – and HP needs to work on the touchpad's palm rejection, which isn't clever enough.

Far more irritating is that HP uses proprietary pins to charge the keyboard rather than USB-C. I'm sure this is purely a size issue, as the keyboard has to be super-slim to fit inside the folded panel during travel, but I'm also sure that I would lose the charger. My early test machine also kept losing the Bluetooth connection with the keyboard, but that should be fixable with a firmware update.

Switching to all-in-one mode, there are two downsides to HP's reliance on a kick-out stand. One is that it means the screen only works in landscape mode – the Lenovo offers portrait as well – while it only sits stably at one angle.

I also didn't like the lightness of the keyboard; Lenovo's is heavier and even attaches magnetically to the foot of its stand. This locks it into place, while HP's keyboard slides around on a desk. I also prefer the feel of Lenovo's keys.

■ Lasting power

Where the Spectre 17 Fold has a clear trump card is portability. Not merely its compactness, but that HP finds

ABOVE The slim keyboard fits inside the folded screen when you're on the move

room for a 94Wh battery, and that means chart-topping battery life: over 11 hours in PCMark's Modern Office test in full-screen mode and 12-plus hours in laptop mode. That's four more than the ThinkPad and three better than the Asus, both of which

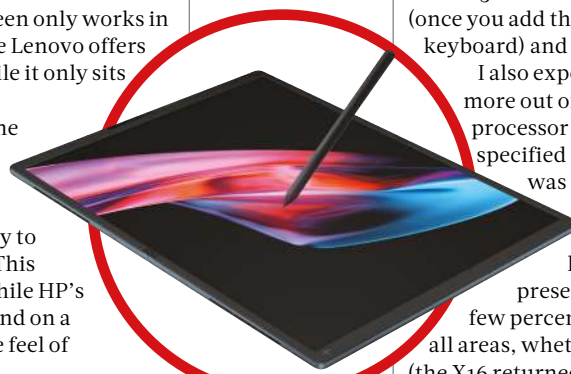
have smaller batteries.

HP also wins for weight. At 1.6kg, it's 300g lighter than the ThinkPad with all its trappings, and shaves 200g off the Asus Zenbook 17 Fold. The

Spectre is far slimmer, too, measuring 21.4mm at its thickest compared to almost 30mm for Lenovo's offering (once you add the stand and keyboard) and 31.9mm for the Asus.

I also expected HP to squeeze more out of the Core i7-1250U processor than its identically specified rivals, because there was always notable hum coming from the fans. Nothing too loud, but almost ever present. Instead, it scored a few percentage points worse in all areas, whether in Geekbench 6.2 (the X16 returned 7,711 in the multicore section, 5% more than the HP), Cinebench R23 multicore (6,228 for the X16, 4,130 for the Spectre) or 3DMark Time Spy (1,391 versus 1,193). In truth, though, I wouldn't base

"Films look great on the Spectre, but I was most taken by the speakers; listening to music is a genuine pleasure"



ABOVE The bundled HP Tilt Pen snaps to the side of the Spectre and is a joy to use

any buying decision between the three on benchmarks. None of these machines is a speed demon but they're all quick enough to handle most tasks.

Screen quality

I wouldn't allow the HP's extra 0.7 inches of viewable screen area to sway me, either. All three panels are cut from similar cloth, with excellent colour coverage – 100% of the DCI-P3 gamut with an average Delta-E of 0.44 in the Spectre's case – and superb sharpness. And while the HP only hit 399cd/m², compared to 467cd/m² for the X16, OLED's perfect contrast makes it easy to view in everything bar direct sunshine.

Films look great on the Spectre, but I was most taken by the speakers; listening to music is a genuine pleasure. When I played "Englishman in New York" I almost felt that Sting was hiding behind the display, such was the clarity. Nor does the Spectre Fold suffer from the crushing together of instruments you often hear on laptops, with

everything clearly delineated.

Switching back to work mode, the mics are superb during video calls, while the 1080p webcam captures great detail even in darker conditions.

There was one more surprise to come: the stylus. This snaps to the right of the

Spectre when in desktop mode, where it also charges wirelessly. It takes a real effort to separate it from the chassis, so this is one pen you shouldn't lose. The tip even feels nice against the screen. My drawing skills never graduated beyond a house with stick men inside, but I can imagine digital artists creating great things on the 17in canvas.

Final thoughts

HP gets so much right with this three-in-one PC. Its webcam, speakers, portability, battery life and stylus combine to lift it above the Lenovo. But then there are the areas where it

LEFT You can put the top of the keyboard onto the screen, and the rest folds down

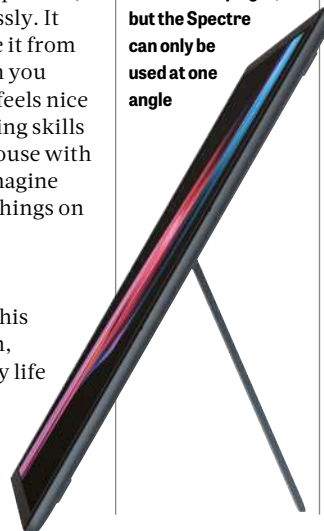
BELOW A discreet kick-out stand keeps the screen upright, but the Spectre can only be used at one angle

falls behind: it's slower and noisier than the X1 Fold, plus the keyboard is more annoying. Lenovo also wins with a three-year collect-and-return warranty, while HP supplies a miserly single year's return-to-base cover. You can extend HP's cover to match Lenovo's for £149 at time of purchase, and I recommend you do so as no element of this machine is repairable.

The basic warranty is made all the more surprising considering how much HP is asking for the Spectre Fold 17. I can see professionals justifying the outlay for the X16 Fold, but surely the consumer-focused Spectre Fold only starts to make sense at £3,000? Until the price tumbles to that kind of figure, and despite this computer's many merits, it simply isn't worth buying. **TIM DANTON**

SPECIFICATIONS

10-core (2 P-core, 8 E-core) Intel Core i7-1250U processor • 16GB LPDDR5-5200 RAM • Intel Iris Xe graphics • 17in 2,560 x 1,920 60Hz OLED touchscreen • 1TB M.2 PCI-E Gen 4 SSD • 5MP webcam • Wi-Fi 6E • Bluetooth 5.3 • 2x Thunderbolt 4/USB 4 • 94Wh battery • Windows 11 Home • HP Tilt Pen • unfolded, 376 x 277 x 8.5mm (WDH); folded, 277 x 191 x 21.4mm • 1.3kg (1.6kg with keyboard) • 1yr RTB warranty • part code 8R2R4EA#ABU



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Apple MacBook Air 13in (M3)

A tweaked design – farewell fingerprints – and lower starting price make the best ultraportable in the world even better



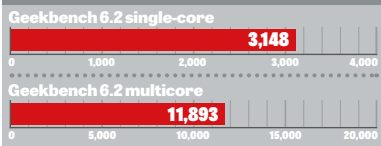
SCORE ★★★★★

PRICE As reviewed, £1,249 (£1,499 inc VAT) from apple.com/uk

Apple's third-generation M3 processor debuted in last year's MacBook Pro and iMac computers; now it comes to the MacBook Air, making this the most powerful thin and light laptop the company has ever offered. Even better, the new entry-level model costs £150 less than the 2022 M2-powered version. That older model remains on sale, now at a more tempting £999, while the original 2020 M1 Air has been discontinued.

While the base M3 model's price is a nice surprise, what's less welcome is the fact that it still only bags you 8GB of memory and 256GB of storage. In 2024 that is tight: even if it suits your needs for now, it's hard to feel confident that it will remain adequate for the lifetime of the laptop. And one of the MacBook's major limitations is that you can't upgrade the hardware after the point of purchase.

BENCHMARKS



BATTERY LIFE



Upgrades are also expensive. You'll pay an extra £200 on top of the base price to step up to 16GB of RAM, and the same again to double the basic 256GB of storage to a roomier 512GB. The top-of-the-range model with 24GB of RAM and 2TB of onboard storage will set you back £2,299. As a sweetener, all configurations beyond the entry-level model come with a boost in graphical performance: the regular M3 chip has eight CPU cores and eight GPU cores, but higher-spec MacBook Air models including an extra two GPU cores.

Sharp-looking design

The M3 13in MacBook Air looks identical to the M2 version. That's as expected: the previous model introduced a bold new design, with a slim casing, thin bezels and a much classier look than the original wedge-shaped M1 MacBook Air.

There is one subtle physical difference between this and the previous-generation MacBook Air. The Midnight colour option now benefits from a "breakthrough anodisation seal to reduce fingerprints" – presumably a response to criticisms of how easily fingerprints and scuffs showed up on the body of the previous model. And it is indeed more smudge-resistant. If you're not a fan of the dark blue colour scheme, you can order the MacBook Air in Starlight, Space Grey or Silver.

ABOVE The M3 MacBook Air is arguably the best laptop you can buy



"The manufacturing process has been refined so that this is the first Apple laptop product to be made with 50% recycled materials"

BELOW Continuity allows you to move seamlessly between your Apple devices



The manufacturing process has been refined so that this is the first Apple laptop to be made with 50% recycled materials. The body uses 100% recycled aluminium, while the main logic board uses 100% recycled copper; it would be even greener if you could upgrade or repair it yourself, but let's not expect miracles.

Port-light connectivity

The MacBook Air M3 offers the same minimal set of connectors as before: two USB-C 4 ports with Thunderbolt 3 support for speeds up to 40Gbits/sec, a MagSafe 3 port for charging and a 3.5mm headphone jack.

However, where last year's M2 model only supported Wi-Fi 6 for wireless networking, the new M3 version has been upgraded to Wi-Fi 6E, giving a potential performance boost. At some point this technology will be surpassed by Wi-Fi 7, but for now it keeps the MacBook Air reasonably up to date.

Considering how few physical connectors there are, it's irritating that the power and USB ports are all on the left-hand side. This makes cable management fiddly if you're using them all at once, and it means you have no neat option to charge the laptop from the right, even if you're using a USB-C charger rather than the supplied MagSafe one.

■ Starry-bright display

As usual with Apple, the new MacBook Air's screen looks great. The 13.6in IPS display is bright and vibrant, and the native 2,560 x 1,664 resolution delivers a pleasingly sharp and detailed image. It's not as sumptuous as the displays on the latest MacBook Pro models, which now feature mini-LED technology for stunning contrast, plus adaptive refresh rates of up to 120Hz for smooth scrolling and animation. Even so, it's more than satisfactory for work and play.

If you want more desktop space, you can step up to the 15in model – see overleaf – but alternatively you can now connect two external monitors to the MacBook Air at once, one at up to 6K resolution and the other at 5K.

This is a notable improvement over the M2 model, which could only handle one external monitor, but it comes with a rather large caveat: you can only run the second monitor with the MacBook Air's screen closed. Opening the lid instantly turns off one of the screens, so you can't work across three screens at once. For office workers who use their laptop in a dock this may not be an issue, but it's a curiously inelegant implementation.

■ Heavy-hitting power

While the M3 is certainly a powerful chip, it's not at the top of Apple's range. The current MacBook Pro series can be ordered with premium M3 Pro and M3 Max processors, while the MacBook Air is only available with the common or garden M3. That makes sense, as it's not intended for heavy-duty creative tasks.

As I've mentioned, however, there are two versions of the M3 chip – a base model with an eight-core GPU, and a slightly more powerful version with a ten-core GPU. This was the model I tried, with 16GB of memory and an integrated 512GB SSD, but I'd be surprised if the entry model was noticeably slower.

And the M3 MacBook Air I tried performed brilliantly; macOS Sonoma felt fast and responsive, and there's now a large library of apps that are built natively for the Apple Silicon architecture to take full advantage of the hardware. I tried demanding apps such as Photoshop and Ableton Live 11, and the MacBook Air proved fast and dependable.

The Air even made a decent fist of playing modern, graphically intensive games. I put it through its paces in several titles, including a fast-paced racing simulation, and while performance wasn't up there with the best Windows gaming laptops, the experience was smooth and fun. Indeed, it's a joy to be able to play such games on a thin, fanless laptop,

rather than the bulky, noisy beasts I'm accustomed to.

On that note, it's worth affirming that, like previous models, the M3 Air is passively cooled – so, whether you're pushing it hard in an intensive 3D game or crunching through numbers in a database, there's no fan noise. Again, that's a pleasant change from Windows laptops, which often fire up their fans at the drop of a pixel.

A final aspect of performance worth mentioning is the new MacBook Air's AI capabilities. Apple's M-series chips have long been ahead of the game on this front: while Intel is only now starting to ship processors with built-in NPUs (neural processing units), Apple is onto the third generation of its AI co-processor, and the new, upgraded 16-core Neural Engine in the M3 chip is purportedly faster and more efficient than previous generations.

As discussed in this month's AI PCs feature (see p28), Apple's rivals have usurped it in terms of raw numbers. But as always, it's about the software as well as the hardware. When I tried the Air out with on-device AI features in Pixelmator Pro and Photoshop, I found performance slick and impressive. With everything handled by the M3 chip, you don't need to rely on an internet connection or an external subscription to benefit from AI-assisted tools.

■ Lung-busting battery

Apple claims the new MacBook Air can last 18 hours playing video on a single charge. However, our tests didn't bear this out. My fully charged M3 MacBook Air played a looping 1080p video for 14hrs 19mins before shutting down – a drop from the 16hrs 6mins the M2 version managed in the same test.

That's a shame, but there's still easily enough juice here to get you through a full work day, or even two days of light use. Compared to a Windows laptop, the Air provides stellar battery life.



ABOVE The Midnight colour option has an anodised finish to reduce smudges

“It's rather a joy to be able to play such games on a thin, fanless laptop, rather than the bulky, noisy beasts I'm accustomed to”



ABOVE Unplugging the MacBook Air from the mains has no obvious impact on performance

BELOW The 15in Air (left) offers 20% more screen area than the 13in model

A last strength of the Apple architecture is that unplugging the MacBook Air has no conspicuous impact on performance. I dare say some throttling is going on behind the scenes to maximise battery life,

but macOS and apps feel as fast as they do when running off the mains.

And like other MacBooks, the M3 MacBook Air consumes almost no battery in sleep mode, so you can leave it untouched for days on end, then open it up and start working right away, without having to charge up. Allow some time for recharging, however: the included 35W charger took me from empty to a little over 50% in less than an hour.

■ Air-apparent choice

The new M3-powered MacBook Air isn't as radical an update as the M2 model, but it doesn't need to be. It keeps all the good points of the previous generation, and adds a faster processor, better monitor support and better Wi-Fi, all for a lower price.

True, once you tack on pricey RAM and storage upgrades, it doesn't feel like such a steal; even so, I have no trouble recommending the new 13in MacBook Air. It's not just the best-value MacBook, it's arguably the best ultraportable there is.

MATT HANSON

SPECIFICATIONS

8-core Apple M3 chip with 10-core GPU ● 16GB unified memory ● 512GB M.2 PCI-E Gen 4 SSD ● 13.6in non-touch IPS display, 2,560 x 1,664 resolution ● Wi-Fi 6E ● Bluetooth 5.3 ● 2 x Thunderbolt 4/USB-C 4 ports ● MagSafe 3 charging port ● 3.5mm headphone jack ● 1080p FaceTime HD webcam ● 53Wh battery ● macOS Sonoma ● 304 x 215 x 11.3mm (WDH) ● 1.2kg ● 1yr RTB warranty





Apple MacBook Air 15in (M3)

A big-screen companion that's light for its size and ready for work, entertainment and AI

SCORE ★★★★★

PRICE As reviewed, £1,249 (£1,499 inc VAT) from apple.com/uk

Sometimes I struggle to explain why you'd want a larger, heavier version of the MacBook Air. It's especially difficult this year because, aside from its size, the new M3-powered 15in MacBook Air looks and performs an awful lot like the 13in version.

Of course, the price is different. Where the 13in model starts at £1,099, the plus-sized version costs £200 more with 8GB of RAM and a 256GB SSD. There's an argument for going beyond the entry-level spec, especially as the bigger screen lends itself to graphical and video work. Upgrading to 16GB of RAM or a 512GB SSD will add £200 to the cost, with options up to 24GB of RAM and 2TB of storage for a total of £2,499. Whichever specification you opt for, all 15in models come with the same M3 processor, comprising eight CPU cores and 10 GPU cores.

The chassis has the same pleasing aesthetic as the smaller model – all neat lines and buffed corners. It's made of recycled aluminium, with an anodised finish on the Midnight colour scheme that does a fair job of repelling fingerprints.

At 1.5kg it's only 270g heavier than the 13in model, so it's quite light for a 15in laptop.

The 15in model has the same minimal set of connectors as the 13in one – frustrating given how much unused space there is around the sides. The two Thunderbolt sockets on the left edge can drive two external displays (or one plus the laptop's own screen), but on the other side there's nothing but the 3.5mm headphone jack. A third USB socket would have

made a big difference, so here's hoping it comes in the next update.

Despite the similarities in design, the larger MacBook Air feels quite different to use. The bigger palmrest makes typing more comfortable, and the expanded body allows for a huge force-touch trackpad. The lower case houses six integrated loudspeakers, rather than the four of the 13in model; these provide an impressively clean, powerful sound, with the force-cancelling woofers offering decent bass without distracting vibrations.

The other palpable benefit is the bigger screen, with its 2,880 x 1,864 resolution providing a workspace that's more than 20% bigger than that of the 13in model. You won't spot any differences in quality: it has the same 224ppi sharpness as the 13in MacBook

Air and matches it for colour accuracy and brightness.

In our benchmarks the 15in model scored 3,102 in Geekbench 6.2's single-core test and 12,052 in the multicore test. That's a big step up from the M2-based 15in MacBook Air and almost an exact match for the new 13in model – which is hardly surprising, since they both use the exact same silicon.

I saw similarly positive results when trying out AI functions using the M3's Neural Engine co-processor and when gaming: the M3 is plenty powerful enough to handle modern games, but if you want to play AAA titles at a smooth 60fps you'll probably need to reduce the resolution to 1080p.

Nor can I complain about battery life. The 67Wh internal battery is 26%

ABOVE The 2,880 x 1,864 screen is more than 20% bigger than that of the 13in model



"I think the 15in MacBook Air is a great deal. After using it for a week I've grown attached to the spacious format"

LEFT The bigger palmrest on the 15in model makes typing more comfortable

larger than the one in the 13in variant, and Apple claims that this matches the smaller model's 18 hours of video streaming. While that's perhaps an optimistic measurement, I got over 15 hours of continuous web browsing on the 15in MacBook Air, putting this laptop on a par with its regular-sized cousin. I wouldn't have minded an even larger battery, but that would have meant more weight, and as things stand there's certainly enough juice here for all-day usage.

In all, while the 15in Air has much in common with the 13in model, it also has additional benefits: a bigger touchpad, better speakers and, of

course, a bigger screen – with no compromise in battery life. The only downsides are that it's significantly less portable, and the higher price might make you wonder whether it would be worth saving

up the extra for a 14in MacBook Pro.

Personally, I think the 15in MacBook Air is a great deal. After using it for a week I've grown attached to the spacious format. The power of the M3 chip is reassuring, too. And while this laptop lacks the MacBook Pro's breadth of connectors and its best-in-class display, it feels fast, flexible and ready for anything.

Overall, if you're looking for an everyday laptop with enough desktop space to be productive, the big-screen MacBook Air is a superb choice. It's better looking and faster than almost any other 15in laptop we've seen, and the price compares with the best of them. **LANCE ULANOFF**

SPECIFICATIONS

8-core Apple M3 chip with 10-core GPU • 8GB unified memory • 512GB M.2 PCI-E Gen 4 SSD • 15.3in non-touch IPS display, 2,880 x 1,864 resolution • Wi-Fi 6E • Bluetooth 5.3 • 2 x Thunderbolt 4/USB-C 4 ports • MagSafe 3 charging port • 3.5mm headphone jack • 1080p FaceTime HD webcam • 67Wh battery • macOS Sonoma • 340 x 238 x 11.5mm (WDH) • 1.5kg • 1yr RTB warranty

LEFT Like the 13in MacBook Air, the 15in version is made from recycled aluminium





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Asus ROG Zephyrus G14 (2024)

A gaming laptop for all, with a refined Ultrabook-style design and a gorgeous OLED display

SCORE ★★★★★

PRICE RTX 4070, £1,999 (£2,399 inc VAT)
from uk.asus.com

I was worried about the 2024 Asus ROG Zephyrus G14. Change is scary and this is one of my favourite gaming laptops of all time. I've had my hands on each release since 2019, and loved every second I've spent with these miniature powerhouses. A complete redesign, the sacrifice of RTX 4080 and RTX 4090 options, a new screen type – all announcements that had me holding my breath anxiously during CES.

After two weeks with the latest Asus ROG Zephyrus G14 in hand, though, those updates have won me over. This is a much slimmer model, dropping the chunky base plate required for heavier RTX 4080 and 4090 cards and adopting a mainstream, ultralight profile. Even compared to a non-gaming ultraportable it's skinny at 16.3mm, down a full 4.2mm from last year's G14. The new Blade 14 comes close at 16.8mm, but that weighs 1.8kg compared to 1.5kg for the Zephyrus.

Radical redesign

It's also obvious that Asus is taking the Zephyrus G14 beyond its gaming roots. The dotted LED matrix display of yore has been replaced by a slick diagonal stripe of glass running along the back of the lid. This looks stylish and can be illuminated with 28 mini LEDs for added flair. That more restrained aesthetic, combined with the unibody CNC milled aluminium chassis, gives the G14 a strong MacBook feel. Initially, I even confused the G14



with my MacBook Pro when carrying the device around, due to the soft-touch light silver finish and flat square design – even the rounded corners feel like a Jony Ive touch.

That luxury extends to the build quality as well. Try as I might, I was unable to flex the main baseplate, and while there's a little flexibility to the lid it's one of the sturdier screens I've tested. The whole clamshell is comfortably opened with one hand, with a smooth hinge designed to keep hot air away from the display. That does mean sacrificing the drop hinge I loved on the previous model in favour of a more unified design – with no rise to the keyboard, either.

Super screen

Asus has also swapped out last year's Nebula mini-LED display for a Samsung-designed OLED panel, and it's a revelation. The incredible contrast and super-fast response times marry perfectly with a bolstered 2,880 x 1,800 resolution to produce an incredibly vivid picture. Everything jumps off the screen here – forget the dappled sunlight and vivid green hues of *Assassin's Creed: Odyssey* or the almost alien glow of *Cyberpunk 2077*, I was impressed just watching

developer logos splashing across the screen on boot.

Colour coverage and accuracy proved respectable, with 81% of the DCI-P3 gamut on show with an average Delta E of 0.3. In SDR mode, brightness peaked at 394cd/m², pushing up to a 623cd/m² maximum in HDR mode. That's a strong figure for a laptop.

ABOVE The design is stunning, and the OLED panel produces incredibly vivid images



“Even compared to a non-gaming ultraportable it's skinny at 16.3mm, down a full 4.2mm from last year's G14”

The keyboard is more of a compromise. The keycaps are generously sized until you come to the half-width cursor keys, making them difficult to hit in frantic gameplay. Still, a good amount of space around the left and right arrows meant I could find them without having to scan. Each key actuates with a soft but satisfying clack and a tactile feel – they're also covered with a pleasingly smooth finish. The only omission is a dedicated macro key for switching

between performance modes, as you'll see on larger ROG laptops.

Nor does the 2024 Asus ROG Zephyrus G14 compromise on ports.

Everything but Thunderbolt 4 is catered for here (due to the AMD build), with plenty of options on both sides of the rig for additional flexibility.

Turn of speed

Asus opts for an AMD Ryzen 9 8945HS processor across all models, with either an RTX 4050, RTX 4060 or RTX 4070 GPU at the helm. That CPU is an iterative upgrade over the Ryzen 9 7940HS in last year's machine, and the newer model actually fell slightly behind in PCMark 10 with a score of 7,697 compared to 7,864 for the 2023 equivalent. But it was nip and tuck, with the 2024 version returning 1,791 in CrossMark versus last year's 1,742, for example.

My test unit was running an RTX 4070 GPU, so it naturally won't be competing on the same level as the previous generation's RTX 4090. Still, three-figure frame rates were the norm here – and they shouldn't be taken for granted. After all, this is a slimline gaming laptop housing



ABOVE The glass stripe on the back can be illuminated with 28 mini LEDs

LEFT Aside from the stripe, the Zephyrus G14 resembles a MacBook Pro



power that would have been unthinkable a few years ago.

Overall performance puts the 2024 Zephyrus G14 on par with last year's Razer Blade 14 – sometimes edging ahead and sometimes dropping behind. Both of our test machines in this match-up were running RTX 4070 GPUs, though the Blade 14 uses an AMD Ryzen 9 7940HS CPU. Given the minor upgrades to this year's chip, that won't make much difference.

Gaming benchmarks

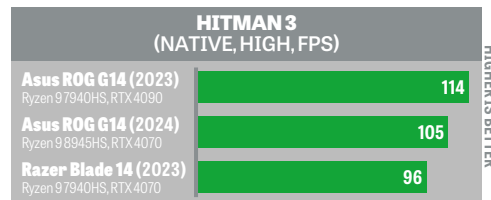
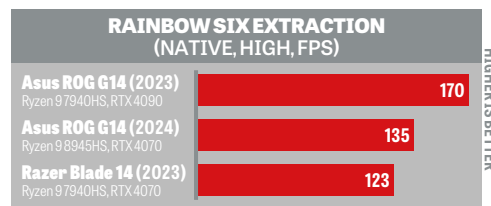
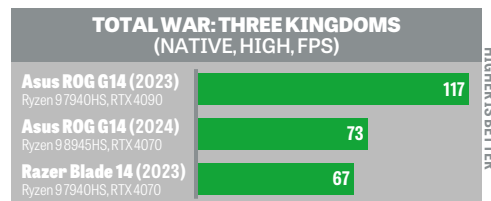
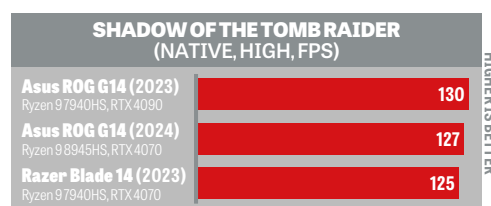
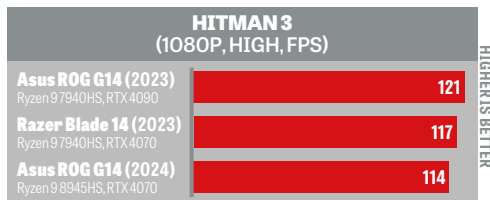
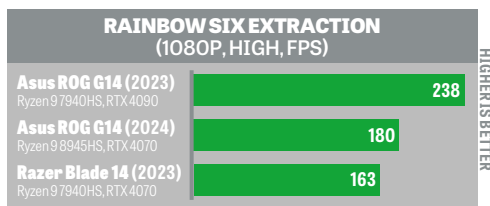
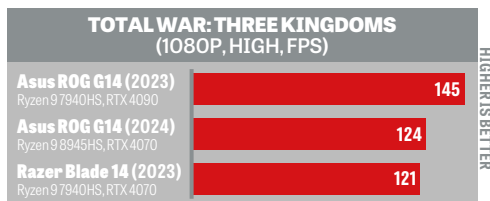
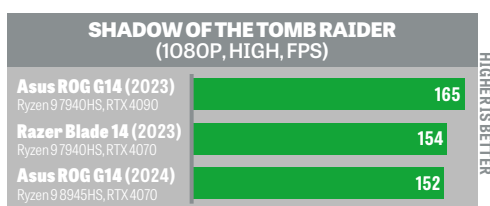
In Asus' Performance mode, 3DMark benchmarks put the Asus ROG Zephyrus G14 roughly 5% behind the Razer Blade 14, but when I activated the system's Turbo mode – delivering its full 90W potential – those numbers took a healthy jump. I averaged an 11,531 score in Time Spy and 25,952 for Fire Strike with those fans running at full power.

Using in-game benchmarks, the Asus ROG Zephyrus G14 put on a great show. While I saw symptoms of that skinny chassis in some top-end QHD+ results, it returned more-than-playable frame rates even in demanding titles. I've seen far lower numbers in chunky (but considerably cheaper) gaming laptops running the same RTX 4070 graphics cards, so pulling off this kind of reliable performance in a miniature chassis is a great achievement.

The Zephyrus G14 dropped behind the Blade 14 at 1080p in *Shadow of the Tomb Raider*'s benchmark, but pulled away from it at native resolutions. Nor does the drop down to an RTX 4070 cut so deep here. Last year's test machine averaged 165fps at 1080p at High settings, and 130fps at QHD High – not a million miles away from this year's 152fps/127fps in the same categories. At these heights, that's far from a sacrifice.

The Three Kingdoms' Battle benchmark often poses gaming laptops a higher threat, with massive scenes rendering an abundance of tiny little warriors and all the special effects they command. Here, though, the Zephyrus G14 held out well, beating the Razer Blade 14 across both FHD and QHD+ resolutions. That RTX 4090 comparison is starker with this more chaotic task, though. Ultra QHD+ frame rates took a plunge, kicking the 2024 model to 73fps while the 2023 version sailed through at 117fps.

Returnal is perhaps a better indication of what's to come down the lifetime of this laptop. I don't have figures for the Razer Blade, but the differences between the RTX 4070 and RTX 4090 are clear in the ROG Zephyrus' results: the 2024 edition



averaged a shade over 60fps at QHD Ultra settings, the 2023 version a steady 120fps. Scoring over 60fps is a strong result, but with heavier games on the way these components may not stand the test of time.

Knockout punch

I can't remember the last time I told someone looking for a 14in gaming laptop not to buy an Asus ROG Zephyrus G14. This year is no different, but my recommendation comes with a caveat. If you're chasing frame rates and wish to play the latest games at ultra settings for years to come, it's worth considering the older 2023 model. You're still getting a

"I can't remember the last time I told someone looking for a 14in gaming laptop not to buy a ROG Zephyrus G14. This year is no different"

BELOW The keycaps are generously sized apart from the half-width cursor keys

super-portable device but, as my testing shows, more demanding titles put that RTX 4090 GPU on show.

There's a big "but" here, though.

An RTX 4070 is more than capable of seeing you through today's games, and those likely to come in the next couple of years, comfortably. Especially if you don't push settings to the max and are happy to

rely on DLSS features.

For most people, the new Asus Zephyrus G14's improved aesthetics, lightweight footprint and astonishing display more than make up for the frames per second you lose compared to an RTX 4090 system – which is also far more expensive. Considering that you'll barely notice that dip in performance when enjoying frame rates above 100fps, it's an easy trade to make.

TABITHA BAKER

SPECIFICATIONS

8-core/16-thread AMD Ryzen 9 8945HS processor • 8GB Nvidia GeForce RTX 4070 graphics (up to 90W) • 32GB DDR5-6400 RAM • 14in non-touch, 120Hz OLED display, 2,880 x 1,800 resolution • 1TB M.2 PCI-E Gen4 SSD • Wi-Fi 6E • Bluetooth 5.3 • 1080p webcam • USB-C 4 • USB-C 3.2 Gen 2 • 2x USB-A 3.2 Gen 2 • HDMI 2.1 • UHS-II microSD card reader • 3.5mm combo jack • 73Wh battery • Windows 11 Home • 311 x 220 x 16.3mm (WDH) • 1.5kg • 1yr limited warranty • part code: GA403UI-QS060W





Cyberpower Ultra R77 RTX Gaming PC

This visually striking PC packs a powerful punch thanks to a Ryzen 7 7800X3D and RTX 4080 Super combo

SCORE ★★★★★

PRICE £1,895 (£2,275 inc VAT) from tinyurl.com/356cyber

My words won't do justice to Cyberpower's choice of chassis, the dramatic NZXT H6 Flow. It's almost like two chassis: one made of tempered glass that reveals all the RGB-lit components within, the other adding around 100mm to its width where the power supply and ugly cables hide away. And then it's as if NZXT took an angle grinder to it, shaving off a corner for a trio of 120mm RGB fans to suck in air and cool the powerful components within. It's both clever and stylish.

Three more 120mm RGB fans sit at the top of the case, with a single fan at the rear to add more glow. On first launch, the fans run at full speed and you'll hear a mighty roar; your first task should be to load MSI Center and switch to more intelligent fan profiles. The result is an audible but not unpleasant hum, which only rises when you push this PC to its max.

Then again, when you have this much power at your fingertips you'll want to. Your £2,299 buys AMD's gaming-focused Ryzen 7 7800X3D processor plus one of Nvidia's latest cards, the RTX 4080 Super. This dominates the case despite its lack of RGB lighting, a hulk of metal that weighs 1.5kg on its own.

The RTX 4080 Super is only a minor step up from the RTX 4080. Think a handful more cores and a slightly higher boost clock. However, what matters is that Nvidia's new card offers an excellent route for 4K gaming at a competitive price, and the 7800X3D is a brilliant companion. Together, they pushed this PC to 143fps in *Dirt 5*, 135fps in *Shadow of the Tomb Raider*, 103fps in



Assassin's Creed Valhalla and 84fps in *Cyberpunk 2077*. And those results were at the games' most brutal settings, with no DLSS to help. When I switched to 1440p, frame rates jumped to 221fps, 251fps, 160fps and 126fps respectively.

This PC will also be a great choice if you're hoping to run local LLMs, including Nvidia's own Chat with RTX. This allows you to create a GPT linked to your own content, so you get answers relevant to you and don't need to worry about sharing your data to the cloud.

AMD's Ryzen 7 7800X3D doesn't include NPU's – no high-end desktop chips do yet – but it does have brute force in its favour. In single-threaded tasks, one core can boost up to 5GHz from the processor's 4.2GHz base, and that's reflected in strong single-core results of 2,705 in Geekbench 6.2 and 1,756 in Cinebench R23. Its multicore results of 15,147 and 17,827 in those benchmarks emphasise that this computer can handle multithreaded tasks with ease too, but if that's going to be your main usage then upgrade to the 16-core/32-thread Ryzen 9 7950X3D if you can; Cyberpower charges £192 for the privilege.

You should also consider adding more M.2 SSDs at the time of purchase. The price includes the excellent 2TB Kingston Fury Renegade, which returned blistering

sequential read and write speeds of 7,368 and 6,908MB/sec in CrystalDiskMark 8. But 2TB may not be enough, and while the MSI MAG B650 Tomahawk motherboard includes two further M.2 storage slots, they both sit below the graphics card. Good luck fitting M.2 cards in the available space without removing the graphics card. It's far easier to add other storage: unscrew the right-hand side of the chassis and you'll find MSI's modular 850W power supply, a bunch of carefully tied cables and an empty bay for adding two 2.5in SATA drives and a 3.5in hard disk.

There are two more post-purchase upgrades to consider. The first is to add to the two 16GB DDR5 Kingston Fury Beast DIMMs, with two spare sockets available. The second is to fill the single PCI-E x1 slot. I struggle to think what to put in it, though, as the Tomahawk board covers all important bases, including Wi-Fi 6E and a fine selection of ports at the rear, including 2.5GbE, a USB-C 3.2 Gen 2x2 port, three USB-A 3.2 Gen 2 ports, four more USB-A 3.2 Gen 1 ports, and a generous selection of audio connectors. Two USB-A 3.2 Gen 1 ports also sit on the front of the case, along with one USB-C 3.2 Gen 2 port and a headphone jack.

At £2,275, nobody is going to call the Cyberpower Ultra R77 cheap, but that's reflected in the quality of the components, from the power supply to the chassis to the graphics card, which is itself worth almost half the cost of the whole PC. Add in the fact that the first two years of its five-year warranty cover parts, labour and courier costs, and this is a great deal.

TIM DANTON

SPECIFICATIONS

8-core/16-thread AMD Ryzen 7 7800X3D processor • MSI MAG B650 Tomahawk WiFi motherboard • 32GB DDR5-6000 Kingston Fury Beast RGB RAM • 16GB MSI GeForce RTX 4080 Super 16G Ventus 3X OC graphics • CyberpowerPC Master Liquid Lite 360 ARGB AIO liquid cooler • 2TB Kingston Fury Renegade PCI-E Gen 4 SSD • NZXT H6 Flow RGB Black chassis • 850W MSI MAG A850GL PSU • Windows 11 Home • 287 x 415 x 435mm (WDH) • 2yr parts and labour C&R warranty (5yr labour-only RTB) • power, 99W idle, 460W peak

ABOVE The Ultra R77 is a festival of colour with all its fans alight

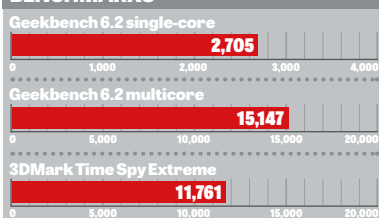


"At £2,299, nobody is going to call the Cyberpower Ultra R77 cheap, but that's reflected in the quality of the components"

BELOW The NZXT H6 Flow chassis looks striking from every possible angle



BENCHMARKS



Save 85% on the A List security suite



Avast Ultimate 2024

WE'VE SECURED AN 85% DISCOUNT FOR *PC PRO* READERS ON THE SECURITY SUITE THAT SWOOPED TO VICTORY IN OUR LABS LAST MONTH

Avast Ultimate 2024 won our internet security suite Labs last month (see *issue 355*, p78), and we've managed to snag 85% off the price. That means £29.99 buys you protection, a VPN and a range of handy utilities and tools for two years across ten devices. That includes PCs, Android devices, iPhones and Macs.

■ Protection for your PC

Avast Premium Security provides a powerful antivirus engine that detects and blocks the latest malware, but not just that: it can help you shop and bank safely, spot fake websites and ransomware, and stop hackers from remotely taking over your device.

You also receive Avast Cleanup, a system maintenance toolkit to remove junk files, control your startup programs, clean and repair the Registry, update installed software and more. In short, it's your one-stop maintenance shop.

Then there's Avast SecureLine VPN, which offers a secure tunnel to the internet, changing your location, hiding your IP address and adding an additional layer of protection. This isn't a cut-down version of Avast SecureLine VPN either, which costs £45 per year all on its own.

The 2024 edition also includes AntiTrack Premium. This blocks trackers as you surf the web, ensuring your browsing stays private.

■ Protection for your phone and tablet

Avast Security Ultimate is similarly powerful for Android and iOS users. As well as the core antivirus and browsing protection, a stack of anti-theft features allow you to remotely locate, lock or wipe your device, use the camera to take a shot of the thief, or have the device automatically lock if the SIM is replaced.

Avast Security will keep your Android device in top working order, while Avast

SecureLine VPN is also included so you can install a VPN on your mobile device.

■ Protection for your Mac

For Mac users, Avast Premium Security and Avast Cleanup Premium are classy desktop apps with real-time antivirus protection, hard drive cleanup tools, a duplicate file finder and more. And Avast SecureLine VPN will give your Mac a VPN that you can use to create a secure tunnel to the internet.

■ Complete protection

You're not restricted to using just one of these products, or one per device: Avast's Ultimate licence covers ten devices, so you can secure all your PC, Apple and Android hardware.

What's more, the £29.99 cost includes a two-year subscription. Compare that to the £194.99 if you bought the products individually, or the £110-per-year renewal price Avast charges on its website.

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AMD Radeon RX 7900 GRE

A good-value 1440p gaming card that fills a gap in AMD's line-up, but Nvidia's RTX 4070 is a better all-rounder

SCORE ★★★★★

PRICE **Sapphire Radeon RX 7900 GRE Pulse, £458 (£550 inc VAT) from scan.co.uk**

The AMD Radeon RX 7900 GRE isn't a new graphics card: it officially launched in China back in July 2023. However, AMD has now allowed its partners to release the Golden Rabbit Edition in the UK, at a price that pitches it directly against Nvidia's RTX 4070 (see issue 345, p56) while hoping to steal sales from the RTX 4070 Super (see issue 354, p58).

AMD's "new" card compares well to the 7800 XT, which costs around £500. Both have 16GB of VRAM, but the 7800 XT has only 60 compute units while the 7900 GRE has 80 – a 33% increase. That compares to 84 for the 7900 XT and 96 for the XTX. At 18Gbits/sec, however, memory bandwidth is less than the other high-end AMD chips, which run at 19.5Gbits/sec and 20Gbits/sec. The reduced bandwidth is one reason for the wider gap than you might expect between the 7900 GRE and the 7900 XT in the graphs below.

AMD sent us the £550 Sapphire Pulse model for review, but at time of going to press Scan sold the superior Pure – which features a modest factory overclock and is finished in white – for £540. If you want RGB lighting as well, search for the 7900 GRE Nitro+.

Still, the Sapphire 7900 GRE Pulse serves well as a reference model. This is a 321 x 127 x 51mm card, with a 2.5-slot width and 1.1kg weight. One bonus of buying a Sapphire card is that it comes with the company's "angular velocity" blades, which excel at producing plenty of airflow without making much noise. And that's again true here.

I'll focus on 1440p gaming, as this is the target market for the RX 7900 GRE. At 1440p with top settings, you can see from our "overall average" chart that it comes in slightly ahead of the RTX 4070, with a 3.4% lead. Typically, you'll find RTX 4070 cards on sale for around £520, so the speed difference is reflected in the price.

Every rasterisation game averaged 80fps or more, while only one ray tracing game out of six cleared 60fps (*Spider-Man: Miles Morales* with an average of 60.3fps). It's the usual story of AMD beating Nvidia in rasterisation and losing in ray tracing.

The RX 7900 GRE proved 9.3% faster than the 7800 XT, which is again almost a straight-line relationship with pounds spent. The 7900 XT leads the GRE by 16.5%, so there's still quite a gap between the new card and the next step up AMD's rung.

ABOVE The RX7900 GRE is a fine choice for 1440p gaming

"For professional workloads, the GRE makes a great alternative to the 7800 XT, being 25% faster in some cases"

Gaming at 4K on the RX 7900 GRE is hit and miss. For most rasterisation games, it's within reach – and games that support AMD's FSR 2/3 upscaling can usually break 60fps. Dropping from ultra to high settings can also help. But ray tracing games at native 4K with maxed-out settings often end up as a slide show, and most need Performance mode 4x upscaling to reach decent levels of performance.

For professional workloads, the GRE makes a great alternative to the 7800 XT, being 25% faster in some cases due to its 80 compute units. However,

those looking for a card to churn through AI tasks should stick with Nvidia.

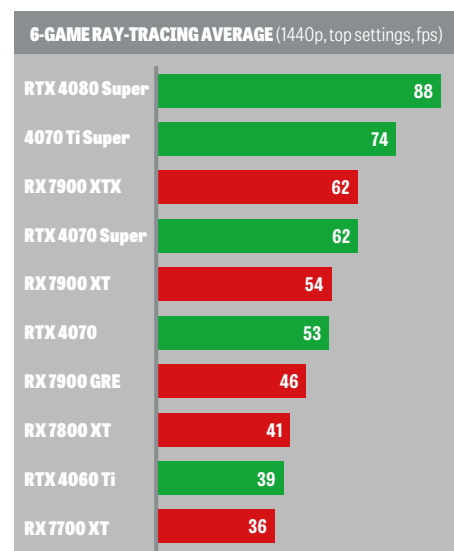
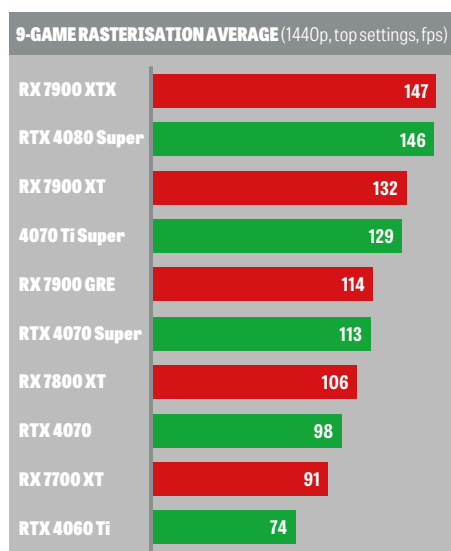
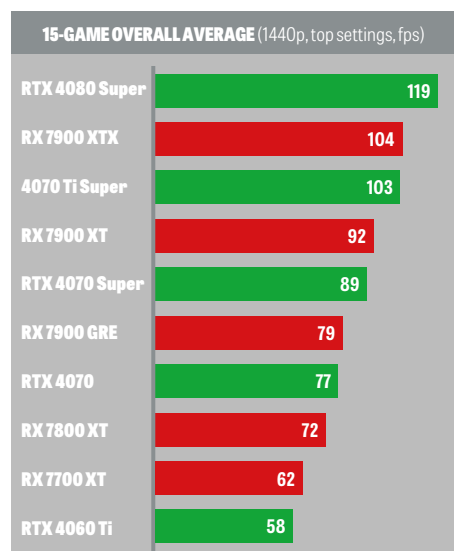
If all you're looking for is a 1440p gaming card, however, the RX 7900 GRE definitely warrants a look.

The Sapphire Pulse model we received for review is particularly impressive in the area of noise, barely registering above the ambient level.

JARRED WALTON

SPECIFICATIONS

PCI-E Gen4 x16 graphics card • 2,245MHz boost clock • 5,120 GPU cores (shaders) • 80 SMs • 160 tensor/AI cores • 80 RT cores • 16GB GDDR6X memory • 256-bit memory interface width • 2 x DisplayPort 2.1 • 2 x HDMI 2.1 • 260W TDP • 324 x 127 x 51mm (WDH) • 2yr limited warranty



Testrig: Core i9-13900K with all cards upgraded with latest drivers

Key: Green = Nvidia cards Red = AMD cards



Honor Pad 9

A great price for a slim Android tablet with impressive battery life, but it's hard to out-iPad the iPad

SCORE ★★★★★

PRICE £250 (£300 inc VAT)
from hihonor.com

On the surface, the Honor Pad 9 is a standard Android tablet. It's sleek and stylish in its matte green aluminium frame, and has the same 16:10 aspect ratio display as most of its Android brethren. But Honor has created the most iPad-like experience I've seen, thanks to MagicOS on Android 13.

In particular, it's solved the user interface problem that beset Android tablets. Simple three-finger gestures drop you straight into multitasking modes (including running two instances of the same app) with ease, while swiping up from the bottom to flip between apps is fast and fluid. You can also connect your Honor phone, tablet and laptop together – if signed in to Honor Connect and on the same Wi-Fi network – to instantly transfer files or link devices together as one giant, virtual desktop.

It even beats the 10th generation iPad (see issue 352, p83) for svelteness, albeit by only 0.1mm, measuring 6.9mm thick to the iPad's 7mm. They have an identical 180mm width, too. The only notable dimensional difference is in height, but that reflects the Honor Pad's 12.1in screen versus 10.9in for the iPad.

It's a great display for the price, too, covering almost 100% of the sRGB space (around 75% of DCI-P3) with

solid colour accuracy. That's similar to the iPad once more, and they share the same peak brightness of around 500cd/m². Where the Honor decisively wins is its 120Hz refresh rate rather than 60Hz. Everything looks smooth as a result.

Films look great on this tablet but, despite the eight speakers spread around Honor Pad 9's edges, there's a tinniness to the sound. Instruments are clear, and surround-sound effects work well, but don't expect bass-heavy miracles. Nor is this a tablet I'd choose to take video calls on: the 8MP front-facing sensor is good enough for occasional WhatsApp chats, but there's a lot of noise on show. The 13MP rear camera generates pictures with less noise, but a mushy lack of detail.

Whilst in critical mood, let's talk power. Qualcomm's Snapdragon 6 Gen 1 is enough for basic productivity tasks and casual gaming, and it's more than powerful enough to display films at their best, but when you push it with CPU-intensive apps, or open up multiple Chrome tabs, you can feel it buckling under the pressure. That feeling is backed up by the numbers. In Geekbench 6's single-core test, the Honor returned 946, to 1,580 for the iPad. In the multicore section, it was a boy's 2,521 to a man's 4,400. There's no Wi-Fi 6 here, either, only Wi-Fi 5.

ABOVE The superb 12.1in display is a match for the iPad

“Honor has created the most iPad-esque experience I've had on an Android slate, thanks to MagicOS on Android 13”

BELOW The optional keyboard turns the Pad 9 into a device you can happily work on

The good news is that's the end of the bad news. Take battery life, where the Honor Pad 9 returned a time of 11hrs 26mins in our video-rundown test. In typical use that drops below the ten-hour mark, but this is iPad territory in terms of longevity.

Honor's tablet supports charging up to 35W, but the 8,300mAh battery takes a couple of hours to recharge.

If you're looking for something to work on, again there's excellent news in the optional keyboard, which comes with a UK layout. The Pad 9 is £300 without it and £350 as a bundle.

If you buy another Honor device at the same time then you may well find that you're offered the Pad 9 at half-price. This was true for buyers of the Honor Magic6 Pro (see p70) as we went to press. Then you can take advantage of Honor Connect, too.

There are still reasons not to buy this tablet. One is that Honor hasn't stated how long it will be supported for, and it's currently on Android 13. Another is that the 9th generation iPad (see issue 327, p52) remains on sale for £369, and that's both faster and gives you access to a wealth of apps that Android simply can't match. Then there's the £449 OnePlus Pad (see issue 352, p86), which is an all-round superior Android tablet.

However, it's impossible to argue with the Honor Pad 9's value for money. For £300, you'll enjoy 256GB of storage compared to the 128GB default of its rivals, Honor also gifts a flip cover rather than charging you for it, and most importantly you're buying a premium 12in tablet with a high-quality screen. **JASON ENGLAND**

SPECIFICATIONS

8-core Qualcomm Snapdragon 6 Gen 1 SoC ● Adreno 710 graphics ● 8GB RAM ● 12.1in 120Hz touchscreen IPS display, 2,560 x 1,600 resolution ● 256GB storage ● 13MP rear camera ● 8MP front camera ● Wi-Fi 5 ● Bluetooth 5.1 ● USB-C 2 ● 8,300mAh battery ● Android 13 with Magic OS 7.2 ● 278 x 6.9 x 180mm (WDH) ● 555g ● 1yr C&R warranty



Synology BeeStation

A super-simple appliance for hosting your own private cloud, with tons of storage and no subscription needed

SCORE ★★★★★

PRICE £174 (£209 inc VAT)
from bee.synology.com

The BeeStation is a novel sort of NAS. While most appliances aim for versatility, Synology's new baby is a stripped-down proposition with one job: to replace Dropbox, Google Drive, OneDrive or whatever cloud storage service you may be using.

The pitch is easy to understand. The BeeStation comes with 4TB of onboard capacity, so you can forget about subscription fees and the worry of running out of space. The drive can be shared with up to eight other users, each with their own private storage area, so for a family or workgroup it can be very economical indeed. And as well as being cheaper than a full-fat NAS, the unit is comparatively small and quiet, with a footprint of only 63 x 196mm.

Setting it up couldn't be easier. Once you've connected it to your router and powered it on, BeeStation Manager (BSM) gets you going with only a few clicks in the browser-based wizard.

To make the most of it you'll also want to install the desktop app for Windows and macOS. This creates a BeeStation folder on your computer, with automatic syncing and on-demand file downloads, in the classic

Dropbox style. File transfers take place seamlessly in the background over any LAN or internet connection, with Synology's QuickConnect platform taking care of the back end.

For on-the-go access you can use the BeeFiles app for Android and iOS, or log into a browser-based file manager. Here you can also browse and restore older versions of files: up to 32 historical file versions can be kept, with optional purging after a certain time limit.

It even gives Google Photos a run for its money, via the BeePhotos app. This automatically backs up images and videos from your phone to the BeeStation, which uses AI-assisted recognition to catalogue the objects, scenes and individuals in your photos. An online gallery view lets you search, organise and share your pictures and albums, and because it's all processed and stored locally, you need have no concerns about mega-corporations exploiting your data.

On top of all this, the BeeStation offers a convenience that no cloud service can match; namely, direct SMB access. This is disabled by default, but flicking a switch in the settings lets you browse the BeeStation like a

regular NAS, and access files directly from your computer without going through the sync agent – a convenient way to (for example) move a large number of files on to or off the device.

The BeeStation fulfils its brief well, but there are caveats. First, be aware this is not a high-performance device: the embedded Ethernet connector is limited to gigabit speeds, and the



single internal hard disk spins at 5,400rpm. That's absolutely fine for everyday cloud syncing, but local access won't be as snappy as a midscale NAS using striped storage and multi-gigabit networking.

If you've any concern for the integrity of your data, alarms bells should also be ringing over the single-drive design. While this keeps the price and the bulk down, it provides zero protection against mechanical failure.

ABOVE The Synology BeeStation is a lot smaller – and cheaper – than a regular NAS



LEFT With 4TB of storage, you shouldn't have to worry about running out of space

I strongly advise you to partner the BeeStation with a large external hard disk; any USB drive can be configured as an automatic backup archive, giving you a way to restore your files if the main disk dies. The extra hardware adds to the price, however, and diminishes the elegance of the setup.

Alternatively, you can make use of Synology's C2 cloud backup service – but while offsite backup has definite advantages, it isn't cheap. If you have 4TB of data to protect, you're looking at a shocking £300 inc VAT per year. While other cloud backup services aren't directly supported, you might find it worthwhile to set up a separate computer to periodically copy files from the BeeStation to a low-cost storage platform, such as Amazon's S3 Glacier.

Finally, it's worth considering whether a regular NAS might be a better investment. A Synology DiskStation DS224+ appliance with a pair of 4TB drives will cost around twice as much as the BeeStation, but it's a much more robust and versatile system that goes far beyond the BeeStation's capabilities. It also gives you scope to upgrade your storage, which isn't supported on the BeeStation – although there are already unofficial online guides that show how to install a larger drive, or replace a faulty one.

"I love the idea of the BeeStation. For almost anyone who doesn't already own a NAS appliance, the benefits are undeniable"

Although the BeeStation has its limitations, I love the idea of it. For almost anyone who doesn't already own a NAS appliance, the benefits are undeniable. Even after

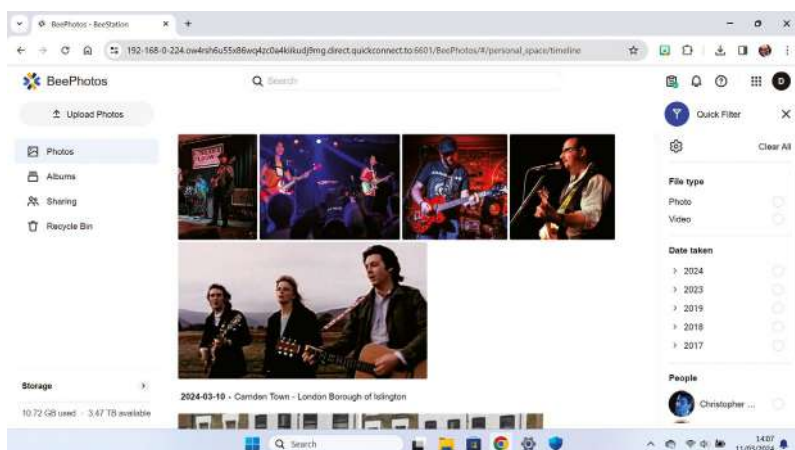
you've added on a backup drive, it remains a neat, affordable little system, which works brilliantly and provides at least a partial respite from the scourge of creeping subscriptions.

DARIEN GRAHAM-SMITH

SPECIFICATIONS

Desktop chassis • quad-core 2GHz Realtek RTD1619B processor • 1GB DDR4 RAM (not upgradeable) • internal 4TB 5,400rpm hard disk • gigabit Ethernet • 2 x USB-A 3.2 Gen 1 ports • 63 x 196 x 148mm (WDH) • 3yr hardware warranty

LEFT The desktop app for Windows and macOS automatically syncs files and photos



Your bonus software

Total value
this month
£155

We scour the globe to negotiate the best software deals for our readers, from extended licences to full programs you don't need to pay a penny for. Here's this month's lineup

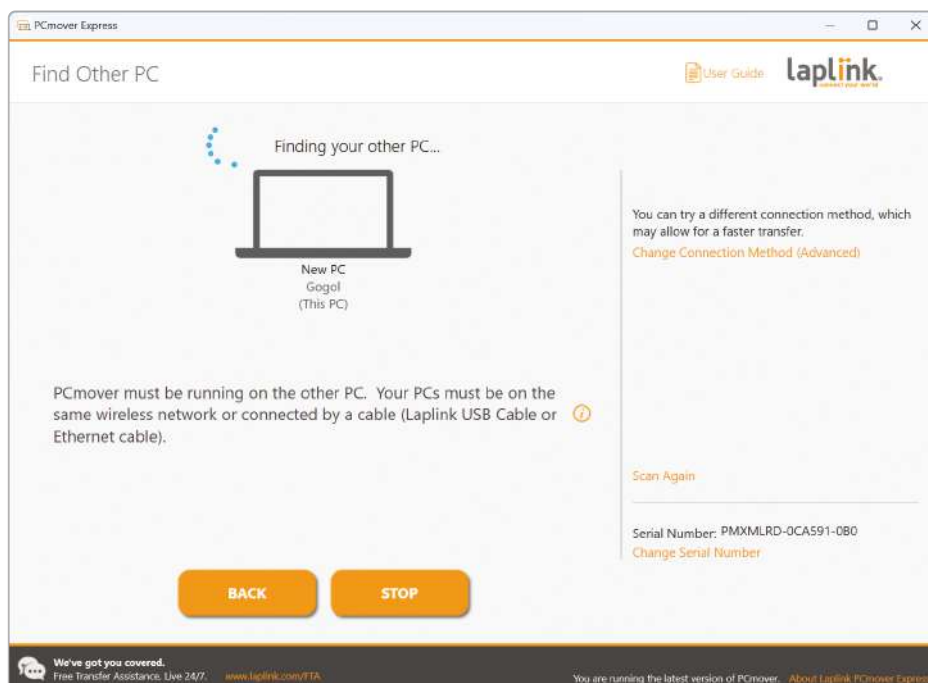
PCmover Express 11.3

Laplink PCmover Express is an easy-to-use tool that helps you migrate your files, settings and other data from an old PC to a new one. It's fully compatible with all versions of Windows from 7 to 11, and is a true set-and-forget application – so you can start it running, then leave it to finish the job while you get on with other things. It's one of the simplest and most effective ways to get your brand new Windows 11 PC ready to use, without the hassle of having to reconfigure everything manually.

■ Full product, worth **£25**
■ **laplink.com** **REQUIRES** Windows 7 or later; 250MB hard drive space; online registration

While PCmover Express automatically transfers the files, settings and profiles you choose, it doesn't migrate your installed applications. As many apps now run in the cloud, getting these set up again should be quick and simple; if you do need to move installed programs, PCmover Professional can handle that task, and currently retails for £42.

Otherwise, PCmover Express walks you through every step of the migration process. Install it on your old machine and it will scan your system to help you decide what to transfer.



Then, simply install a second copy of PCmover Express on your new PC and it will complete the migration for you. The software can automatically discover and connect to your destination PC, and includes a foolproof undo feature.

Note that this version of PCmover will only migrate one user account, with settings and files for the currently logged-on Windows user; other accounts are ignored. It also only copies files from

your system drive. Still, this should help you migrate your most important data smoothly and quickly.

Be aware, too, that files with digital rights management (DRM) controls, or which require keys and serial numbers, may need to be deactivated on your old machine before migrating. Specific hardware drivers also won't be transferred to your new PC, so run a general system update before you start using your new computer.



ABOVE PCmover Express lets you choose whether you want to transfer your user account and settings, personal files, or both



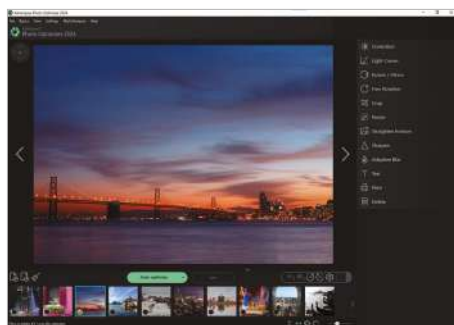
ABOVE You can copy files over your home network, use an external hard disk for faster transfer, or buy a dedicated Laplink USB cable



ABOVE PCmover installs on both your old PC and your new one, so the software takes care of both ends of the migration process

Photo Optimizer 2024

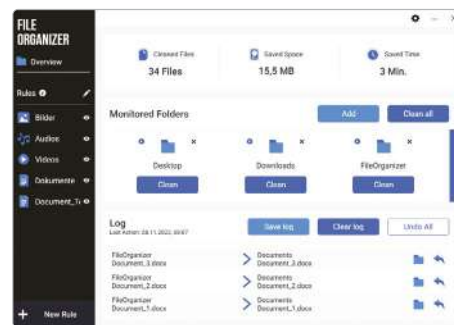
- The easy way to tune and fix your photos, with an intuitive app-like interface
- Crop, resize and rotate images, and automatically apply brightness, contrast and colour corrections
- Includes image auto-rotation based on EXIF data, plus a two-click tool for straightening wonky horizons



■ Full product worth £25 ■ ashampoo.com
REQUIRES Windows 7 or later; 250MB hard drive space; in-application registration

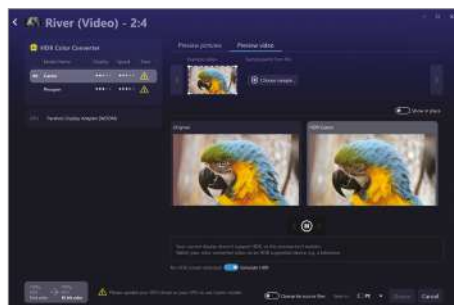
File Organizer 2023

- Use rules that you define to automatically move files to the most appropriate folders on your hard drive
- Also works with cloud services, so files can be automatically uploaded to off-site storage
- Apply advanced selection filters based on file type, filename and even the age of a file



■ Full product worth £40 ■ abelssoft.com
REQUIRES Windows 10 or later; 30MB hard drive space; in-application registration

Vision 2024 SE



■ Full product (excluding MP4 export) worth £20 ■ audials.com
REQUIRES Windows 10 or later; 500MB hard drive space; in-application registration

- This brand new tool uses AI to enhance your videos, and can even upscale HD footage to 4K
- Convert existing video files to HDR, or change their size, format and definition
- Add frames to simulate slow motion, and enhance speech to make dialogue clearer

Backup Maker 8.3



■ Full product worth £35 ■ ascomp.de
REQUIRES Windows 7 or later; 74MB hard drive space; in-application registration

- Safeguard your data with the minimum of fuss and effort, using this wizard-driven backup software
- Choose which files to back up, then set a schedule to ensure they're regularly archived
- Perform full or partial backups and store the results to a range of destinations

Driver Updater 1.26



■ 6-month licence worth £10 ■ auslogics.com
REQUIRES Windows 7 or later; 50MB hard drive space; online registration

- Check for missing drivers and install all or some of them with a single click
- Outdated drivers are quickly identified and listed; update or ignore them as you choose
- Option to schedule a regular driver update check, to make sure you're always running the most recent releases

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Logitech MX Brio 705 for Business

By far the best webcam we've tested, for fun or for business, and while the price is high it's justifiable

SCORE ★★★★★

PRICE £183 (£219 inc VAT)
from logitech.com

Even if you're not familiar with Logitech's MX range of mice and keyboards, the price and all-metal finish gives this webcam's executive aspirations away. But the name isn't merely a marketing signal of intent: Logitech has designed the MX Brio 705 to work in tandem with your MX peripherals, so that if you launch Teams or Zoom then shortcut buttons are automatically assigned.

What sets this webcam apart from rivals, though, is image quality across a range of lighting conditions. There's a swish video on Logitech's website that demonstrates this, rotating through 360° to show the user against a range of backgrounds, including the dreaded sunny-window-behind-you. And it's true: the Brio captures the same, even skin tones whether you're in good, dark or backlit conditions.

I put other webcams through the same tests to see how they performed, and most struggled. They included two older Logitech webcams, with only the similarly priced Obsbot Tiny 4K (see issue 332, p73) matching the Brio 705.

Both include high-end 4K Sony Starvis sensors. The result is superb definition, but also means you can



zoom in during calls and the image will remain crisp – chances are you're only streaming at 1080p anyway.

Naturally, Logitech talks about AI enhancements, too. This is one reason it produces such accurate skin tones in a range of conditions, and because all the work is done at the camera level rather than software you'll reap the benefits in all streaming software.

The Brio 705 ships with Logi Tune, which is a great way to adjust your field of view (65°, 78° or 90°) and zoom. Tick the RightSight option and you lose these options, but the camera will keep you in the centre of the view (this option isn't available for Mac users). Such ease of use, combined with fine control over exposure, vibrancy and sharpness, is one area where Logitech soundly beats Obsbot.

You can also buy a consumer version of the webcam called the MX Brio, which also comes in black but is otherwise identical. You'll be encouraged to load Options+ or the gaming-focused G Hub instead of Logi Tune, but they're essentially identical.

AI again comes to the fore when recording your voice. This, together with a pair of beamforming mics,

ABOVE The Logitech MX Brio 705 is the best webcam we've tested



means the Brio focuses on your voice while reducing background noise. It works, but, as is often the case with noise-reduction technology, it removed a shade of natural timbre.

The main camera unit magnetically fits into the stand, and if you detach it you'll discover a 3.5mm thread for easy mounting on a tripod. Slip it back in and the Brio sits securely in the best webcam mechanism I've used. A hinge means you can rotate the camera unit 90° and the stand stays locked in position on the top of your monitor – and it flips the feed 180° so that people can see what's happening without craning their necks. The assembly fits securely atop a chunky monitor or a slimline laptop, too, and you can even sit it flat on your desk.

A chunky grey privacy shutter is controlled via a satisfying ring around the lens; my only criticism is that you will need to find a way to protect the

"The Brio 705 captures accurate, evenly exposed skin tones whether you're in dark or backlit conditions"

Brio from scratches on your travels as the shutter sits behind this glass rather than protectively in front of it.

Logitech includes a decent two-year warranty but, unlike some of its recent products, this isn't a repairable device. It's

still certified as carbon neutral, thanks in part to the use of recycled plastics and FSC-certified packaging, but if anything goes wrong with the main unit you're out of luck (at least the 1.5m USB-C cable isn't captive).

There is one final deal sweetener, which is that you get one month's free use of Adobe Creative Cloud. Unusually, if you're already a Creative Cloud user, you can also claim an extra month's use for free. It adds up to a truly great webcam; the best I've tested. The only downside is its expense. **TIM DANTON**

SPECIFICATIONS

4K Sony Starvis sensor • 4K streaming at 30fps, 1080p at 60fps • 65°/78°/90° field of view • 2 x beamforming mics • 1.5m cable • USB-C connector • 98 x 52 x 62mm (WDH with clip) • 176g with clip • 2yr warranty

LEFT Image quality is superb, whatever the lighting conditions



Logitech Signature Slim Combo MK950

Sleek, stylish and a joy to use, but the best feature comes via Logitech's Smart Actions software

SCORE ★★★★★

PRICE £92 (£110 inc VAT)
from [logitech.co.uk](https://www.logitech.co.uk)



While the Logitech Signature Slim Combo MK950 may look like a keyboard and mouse, what Logitech really wants to sell you is a promise. The promise that by spending a shade over £100 on this pair of devices, your life will become simpler. More productive. Just generally better.

The key to this is Smart Actions, part of Logitech's Options+ software. Say you have a morning routine where you launch Outlook, Slack and Edge. Or a string of tasks before you close down for the day. Maybe you edit videos in Premiere Pro and regularly change speeds, or you're a coder who repeats the same checks. Whatever the sequence of events, you can assign them to one trigger action and Smart Actions will do the rest.

Well, so long as your commands fall within four broad remits: launching an app (but not Universal Windows Apps such as Netflix), keystrokes, preset text and system actions. For the latter, think closing windows, copy and paste, launching Windows Copilot.

While this idea is hardly revolutionary, two things weigh in Logitech's favour. The first is ease of use: once you've downloaded Options+, you'll need little hand-holding to get going, with a bunch of templates to either use or tweak. The second is that it ties so well to the hardware. There are programmable buttons at the top of the keyboard, and four clickable options on the mouse: the scroll key, a button

beneath it and the two shortcut buttons that sit to the left.

The keyboard uses the same perfunctory scissor-key action as the MX Keys. They're by no means silent, but quiet enough that you won't bother colleagues in the office. (If an IT team buys the "For Business" version of this set, they can also mass deploy them using Logitech Sync.) I would be quite happy bashing out thousands of words per week on this keyboard. It helps that Logitech pays attention to the details, including contoured key tops, a faultless layout and a full-size number pad.

The extra keys are worth noting, too. I particularly appreciate the dedicated screenshot key sitting next to the calculator above the number pad. There's even a button for emptying your recycling bin – but no Microsoft-sanctioned Copilot key.

Recycling brings me to Logitech's sustainability claims, which aren't as strong as I'd hoped. Of course, it uses post-consumer recycled plastics where it can, and the packaging is FSC-certified. However, if a key goes wrong you'll need a Logitech repair centre to sort it out (the warranty is two years) rather than being able to replace it yourself. Also note the use of two AAA batteries here rather than a rechargeable unit. These should last for several months – there's no backlight – but it's one of the few signs of Logitech reducing costs compared to its MX range. Another is that the symbols on top of the keys are stickers

ABOVE Both the keyboard and mouse are well designed and pleasant to use



"I would be happy bashing out thousands of words per week on this keyboard. It helps that Logitech pays attention to the details"

BELOW The Smart Actions software promises to make your life more productive

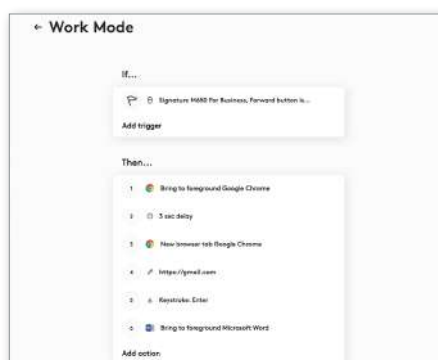
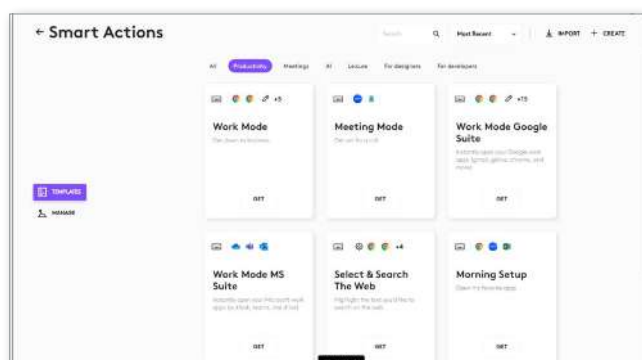
rather than being lasered on, but I suspect they'll still last a few years.

Logitech hasn't sacrificed the MX range's ability to connect the mouse and keyboard to three different devices. You switch between them using shortcuts on the keyboard or a tiny button on the bottom of the mouse. It's a great option for people who need to flick between different computers on one desk, and with Logitech's Flow software you can even move your mouse from one computer to the other seamlessly, as if via a giant extended desktop.

I haven't said much about the mouse as there's little to say. In terms of size, it fits in the Goldilocks zone of

being small enough to take on your travels but large enough that most people – those with huge hands may disagree – will be happy to use it as their main mouse. It also has an excellent scroll wheel.

So, will the Logitech MK950 make your world a better, more productive place? Yes, but only if you embrace the Smart Actions or need to switch between multiple devices. And if you already own Logitech peripherals, they'll still benefit from Smart Actions (just update Options+). However, this is a great way to reap many of the benefits that were previously kept to the more expensive MX range, so I have no hesitation in giving the Signature Slim Combo our Recommended award. **TIM DANTON**



SPECIFICATIONS

K950 keyboard: Bluetooth LE/RF wireless keyboard • 10m range • 2x AAA batteries (supplied) • supports Windows, Linux, Android, iOS, iPadOS and macOS • 296 x 21 x 132mm (WDH) • 506g • 2yr warranty.
M750 mouse: 4,000dpi wireless mouse • Bluetooth LE/RF • 1x AA battery • 83 x 124 x 48mm (WDH) • 142g • 2yr warranty



Honor Magic6 Pro

A world-beating set of cameras and a long-life battery make this one of the best Android phones around

SCORE ★★★★★

PRICE 512GB, £917 (£1,100 inc VAT)
from hihonor.com/uk

The Magic6 Pro's undisputed killer feature sits within the circular unit at the rear, which contains a trio of powerful cameras: one with a 180MP sensor and 2.5x optical zoom, the primary 50MP unit with an adjustable aperture, and a third wide-angle 50MP camera.

Although the Magic6 Pro has many manual controls, it remains a great choice for point-and-shooters like me. At MWC Barcelona (see p14), I used the main lens to capture the city at night to great effect – the graffiti-ridden walls simply looked stunning. This is where the adjustable aperture comes into effect, switching from its standard f/2.0 to a wider f/1.4 setting.

The only area in which this phone's camera falls behind the Galaxy S24 Ultra (see issue 354, p58) is for optical zoom, with 2.5x literally half as good as 5x. This is where a 180MP sensor comes in useful, as you can crop in for a digital zoom while retaining detail, but if you take lots of long-range shots then you'll still appreciate the S24 Ultra's greater fidelity and more vivid colours.

The DXOMark benchmark actually rates the Magic6 Pro's 50MP selfie camera as the best in the world, with particularly strong results for bokeh,



focus, texture and noise levels. The iPhone 15 Pro Max (see issue 351, p62) is better at capturing skin tones, but that's it. Anyone who likes to shoot video on their phone will also be extremely

pleased with the Magic6 Pro's results, with professional results thanks to optical image stabilisation and minimal wind noise.

The 6.8in AMOLED screen – unusually, it has curved edges – is again right up there with the best phones.

It's worth having a play in the settings to find what

you prefer, but I settled on

Natural Tone (which adjusts the colour temperature based on ambient lighting) coupled with the Vivid mode to add extra punch. In Vivid mode, without Natural Tone, it covers 83% of the DCI-P3 gamut with an average Delta E of 1.14, which is a fine set of results. It reached a peak brightness of 775cd/m² in non-adaptive mode, but



ABOVE The phone's rounded edges help, a little, to hide its bulk



LEFT The 180MP telephoto zoom takes centre stage

"Honor uses silicon-carbon technology in the battery rather than lithium-ion. The end result is absolutely spectacular battery life"

most importantly I found it easy to read even in sunlight.

This being a 2024 flagship Android phone, it would have been a shock had Qualcomm's Snapdragon 8 Gen 3 SoC not been inside. As always, this chip flew through our benchmarks. Geekbench 6 returned scores of 2,238 and 6,885, a fraction behind the overclocked version of the chip in the Galaxy S24 Ultra. Good luck spotting that in practice. A 19,467 result in 3DMark's Wild Life Unlimited is again excellent, while the screen's fast touch response times will be appreciated by gamers.

But, most of all, they will come to love the 5,600mAh battery. Honor uses silicon-carbon technology here rather than lithium-ion, which is good news for the environment but also for energy density. The end result in this case is absolutely spectacular battery life, to the point where I could keep going for three days of light use on a single charge. You don't get a charger in the box, but with support for 80W wired charging and 66W wireless it takes between one and one-and-a-half hours to go from zero to full. Again, great scores.

I only have one real criticism of this phone, and that's its bulk. I felt its 229g weight in my pocket, and despite the curved edges and rounded corners there's no hiding from its 8.9mm thickness. This is one of the two prices you pay for a flagship Android phone packed with camera tech; the other, of course, is measured in pounds.

Officially, Honor is selling the Magic6 Pro for £1,100. However, early-bird buyers could claim £250 off that price, reducing it to £850. I can't guarantee the offer will be available when you read this, but if it is then the

Magic6 Pro falls into bargain territory.

Especially as Honor has committed to four years of Android updates and five for security, meaning this phone – and it comes with an IP68 rating and Honor's

own "NanoCrystal Shield" glass – can be considered a long-term investment.

When the Galaxy S24 Ultra costs £1,349 in its 512GB version, which matches the storage here, it's impossible not to recommend the Magic6 Pro. **TIM DANTON**



LEFT The main 50MP camera is superb at capturing images in low-light conditions

SPECIFICATIONS

8-core Qualcomm Snapdragon 8 Gen 3 SoC • 12GB RAM • Adreno 750 graphics • 6.8in 120Hz AMOLED screen, 1,280 x 2,800 resolution • 5G • 512GB storage • IP68 • triple 50MP/50MP/180MP rear cameras • 50MP front camera • Wi-Fi 7 • Bluetooth 5.3 • NFC • 5,600mAh battery • USB-C 3.2 Gen 2 • Android 14 with MagicOS 8 • 76 x 8.9 x 163mm (WDH) • 229g • 2yr warranty

IS TITANIUM



£499.99

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MOB ASUS PRIME H510M-A
RAM 8GB DDR4 2666Mhz
SSD 240GB Sata3 SSD
HDD 1TB Sata3 HDD
OPT 24x DVDRW Dual Layer
GPU Intel Integrated HD630
CAS Fractal Core 1100
PSU 500W PSU
O/S Windows 10/11 64Bit

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£999.99

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MOB ASUS PRIME B660M-A WIFI D4
RAM 16GB DDR4 3200Mhz
SSD 1TB WD SN770 M.2 Gen 4
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PSU 750W Gold PSU
O/S Windows 10/11 64Bit

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CAS KOLINK Stronghold
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GPU AMD Radeon Graphics
CAS 1stPlayer D3-A
PSU 500W PSU
O/S Windows 10/11 64Bit

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Xiaomi 14

A small phone with a big price, but that's justified by the fast processor, strong cameras and generous spec

SCORE ★★★★★

PRICE 256GB, £708 (£849 inc VAT)
from mi.com/uk

Want a compact phone but don't want to compromise on an optical zoom or the latest Snapdragon chipset? Xiaomi has heard your plea, answering with the diminutive, high-quality and rather expensive Xiaomi 14. Not to be confused with the Xiaomi 14 Pro, which isn't being sold in the UK, nor the soon-to-land Xiaomi 14 Ultra.

Even though it isn't branded Pro or Ultra, the plain Xiaomi 14 includes a fine selection of cameras. All three of its rear cameras pack 50MP sensors, covering main, ultrawide and 3.2x telephoto duties. There's also a 32MP selfie camera on the front. Xiaomi's relationship with Leica continues, visible not merely by the branding on the square camera housing but also in the various colour profiles and pro settings in the camera app.

Leica also supplies new camera lenses for greater brightness in images, something that became clear during my tests. Comparing an indoor but well-lit shot of Paddington Station with the iPhone 15 Pro Max (see issue 351, p62), the Xiaomi produced a more colourful image, even if it lacked the contrast of the iPhone. Apple's device proved better at capturing detail in night mode, but here the Xiaomi/Leica partnership produced more natural colours. To compare optical zoom skills, I switched to Samsung's Galaxy S24 Ultra (see issue 354, p58), and again the more expensive phone won out for detail. However, the Xiaomi isn't far off its illustrious rivals.

The Xiaomi 14 even looks like an iPhone at first glance, with its flat display and aluminium sides, but turning the phone over reveals a rounded back panel for a comfier fit in your palm. You have a relatively limited colour selection of black, white or jade green, all of which look



ABOVE For a compact smartphone, the Xiaomi 14 packs impressive specs

good on the matte-textured back glass of the phone. The green option is the most interesting, but only comes in a 512GB option for £899; choose black and you can save £50, so long as you're happy with 256GB.

With an IP68 rating and Gorilla Glass Victus (not the newer Victus 2) to protect the display, I'd expect the Xiaomi 14 to look good for several years to come. Xiaomi offers four years of full updates and five years of security updates, which until recently I would have said was excellent. Now that Samsung and Google offer seven years of full updates for their flagships, though, Xiaomi's policy appears lacking.

Qualcomm's Snapdragon 8 Gen 3 sits within, along with 12GB of RAM across all models, and it performed with predictable panache. More important is the 4,610mAh battery, which is larger than that in the iPhone 15 and the Galaxy S24 (3,349mAh and

4,000mAh respectively). The Xiaomi's battery will easily get you through a full day's work and play. Even better, the supplied 90W charger powered up the phone to 45% in 15 minutes, 80% in half an hour and full after 44 minutes. That's far ahead of the 25W charging offered by the Galaxy S24, which gets to 54% in half an hour.

The AMOLED display features an adaptive 1Hz to 120Hz refresh rate, like every other leading Android phone. Where it stands out is its 1,200 x 2,670 resolution, which sits between common FHD (1,080 x 1,920) and QHD (1,440 x 2,560) standards. This means more detail on the screen than other compact flagship phones, which normally plump for FHD.

Xiaomi claims that the 14's display can go up to 3,000cd/m² in extreme conditions and up to 1,000cd/m² in regular use. Such claims are always hard to test, but to my eyes the Galaxy S24 Ultra's Extra Brightness mode wins out. Nevertheless, the Xiaomi 14 is still strong in this area and overall it's a lovely screen.

I should also mention that the Xiaomi 14 provides a debut for HyperOS, replacing the old MIUI skin. Based on Android 14, HyperOS looks much like the old OS with lots of custom design elements and animation, but it does add a reworked Quick Settings menu that resembles the iOS Control Centre. There are also new underpinnings for inter-device connectivity and AI features, so while HyperOS doesn't live up to the Hyper in its name it may grow into something more interesting with future Xiaomi phones.

It's to Xiaomi's credit that while other manufacturers pour their focus and best tech into their larger phones, it has ensured that its smaller phone

"While other manufacturers pour their focus into their larger phones, Xiaomi has ensured that its smaller phone still gets fun toys"

still gets fun toys. Triple 50MP cameras are rarely found on phones this size, plus it includes better battery, charging and display specs than its rivals. The price is high for a compact phone – a

fraction too high for us to recommend when it falls behind the Galaxy S24 for updates – but luxuries such as Wi-Fi 7 ensure it's a sound long-term investment. **RICHARD PRIDAY**

BELOW The rounded back panel allows for a more comfortable fit in your hand



SPECIFICATIONS

8-core Qualcomm Snapdragon 8 Gen 3 SoC • 12GB RAM • Adreno 750 graphics • 6.4in 120Hz AMOLED screen, 1,200 x 2,670 resolution • 5G • 256GB/512GB storage • IP68 • triple 50MP/50MP/50MP rear cameras • 32MP front camera • Wi-Fi 7 • Bluetooth 5.4 • NFC • 4,610mAh battery • USB-C 3.2 Gen 2 • Android 14 with Xiaomi HyperOS • 72 x 8.2 x 153mm (WDH) • 193g • 2yr warranty

Nothing Phone (2a)

Nothing delivers innovative design, bags of personality and great features for a budget price

SCORE ★★★★★

PRICE 256GB, £291 (£349 inc VAT)
from nothing.tech

The Nothing Phone (2a) (we'll drop the brackets from now on) reminds us that phone design needn't be boring or safe. And with the 2a, Nothing manages to avoid the trap of producing just another iteration on an idea.

And I should know, as I bought the Nothing Phone 1 (see issue 336, p72) on day one before upgrading to the Phone 2 (see issue 349, p72), which I use every day. So I'm already on board with this design-first, disruptive brand. I love how the innards are visible on the phone's rear, turning tech into art, while the Glyph LED system has meant less screen time.

Glyph uses a panel of LEDs on the reverse of the phone that light up and flicker in patterns to signal incoming calls, notifications and more. It's a unique feature that has both been limited and enhanced with the 2a. For while this model has fewer LEDs (three) than previous Nothing Phones, it includes the timer Glyph used by third-party apps that isn't found on Phone 1 (but is on Phone 2). For example, you can use it to monitor food deliveries without constantly checking the screen. Linked to Google Calendar, I use this feature daily to count down to upcoming meetings, so I'm kept in the know without picking up my phone.

The Phone 2a comes with Android 14 and the latest version of Nothing OS, which means new Camera and Media Player widgets plus an AI Wallpaper Generator. Other features absent on the Phone 1 but available on the Phone 2 include the dot-matrix Weather App and the Glyph Composer to craft personalised LED patterns.

You can also replace all the app icons on the phone with Nothing's simplified two-tone dot matrix designs. The idea is to destress the experience of using a screen, removing the colour and clashing

icons with a unified UI. I like it, but others find the colour-limited roster of icons hard to get used to.

Fewer LEDs leaves more room to showcase the circuitry within: this connects the motherboard to the display, SIM card and USB-C port, wiggling up the middle of the phone towards the "head" – that is, the circular unit that holds the two eye-like cameras.

One unique design feature that could easily go unnoticed is that the phone's back is wrapped in curved, clear plastic. This is resilient yet light, all while remaining smooth and tactile. It's a lovely phone to hold.

Placing the two cameras centrally at the top of the phone also makes it more stable on a flat surface, and less likely to glide off smooth surfaces.

Although the way Nothing Phones are designed around the Glyph system, you'll likely keep it face down anyway.

Nothing moves away from Qualcomm's Snapdragon chips, turning instead to the MediaTek Dimensity 7200 Pro. This custom chip offers a modest jump in performance from the Snapdragon 778G used in the Phone 1 (which the Phone 2a replaces), and benchmarks put it just behind Qualcomm's Snapdragon 7s Gen 2.

I tested it using general Google Docs and Sheets, as well video calls, and the Phone 2a didn't miss a beat, no doubt

helped by the generous 12GB of RAM in my review model. This comes with 256GB of storage, and it doesn't seem worthwhile choosing the 8GB/128GB version when it only saves you £30. I also tested the 2a in several games, including *Marvel Snap* on its highest settings, with no lag. Art apps such as Sketchbook were visibly laggy, particularly with a drawing tablet attached, but you can't expect more from a budget phone.

To test battery life I put the Nothing Phone 2a through a demanding day's use, with a mix of gaming, video streaming, productivity apps and web browsing. I first charged the phone from dead, which took a shade under an hour, and after a day's use there was still a fraction under 50% charge left; the joy of a 5,000mAh unit.

You'll be hard-pressed to find a better 50MP main camera in a similarly priced phone. It has a f/1.88 aperture lens and 1/1.56in sensor size, meaning you get excellent macro and portrait results as well as good image quality in low light. It also has a wide 114° field of view, which places it in the company of much more expensive phones such as the OnePlus 12 (see issue 354, p60). When I tested the camera in the low light of early morning I loved the final photos, with superb colours.

Should you buy the Nothing Phone 2a? That boils down to how bored you are with the norm and your desire to use something different. But behind the clever design is a solid smartphone that's powerful enough to handle mainstream apps and games. There are more powerful, larger and more expensive smartphones, but none matches the personality of the Nothing Phone 2a.

IAN DEAN

SPECIFICATIONS

- 8-core MediaTek Dimensity 7200 Pro SoC
- 8GB/12GB RAM
- Mali-G610 MC4 graphics
- 6.7in 120Hz AMOLED screen, 1,080 x 2,412 resolution
- 5G
- 128GB/256GB storage
- dual 50MP/50MP rear cameras
- 32MP front camera
- Wi-Fi 6
- Bluetooth 5.3
- NFC
- 5,000mAh battery
- USB-C 2
- Android 14 with Nothing OS 2.5
- 76 x 8.6 x 162mm (WDH)
- 190g
- 2yr warranty



ABOVE The new Nothing Phone keeps the design flourishes of earlier models

"I love how the innards are visible on the phone's rear, turning tech into art, while the Glyph LED system has meant less screen time"

LEFT The dot-matrix app icons won't appeal to everyone

BELOW The two cameras are placed centrally on the rear, almost like eyes





OnePlus Watch 2

A Wear OS 4 watch that's ideal for OnePlus phone users and a solid alternative to the Galaxy Watch

SCORE ★★★★★

PRICE £249 (£299 inc VAT) from oneplus.com

I'd be the first to tell you that the original OnePlus Watch wasn't worth buying. Launched back in 2021, it brought limited fitness features and a small, clunky selection of first-party apps that left us cold (see issue 322, p74). But that was then: the OnePlus Watch 2 is a fresh, modern wearable that's ready to compete with the Google Pixel Watch 2 (see issue 351, p74) and Samsung's Galaxy Watch 6 (see issue 349, p76).

It starts with a smart new look. The first OnePlus Watch looked basic; the OnePlus Watch 2 is positively stylish. It comes in two finishes, Radiant Steel and Black Steel, with a digital crown and action button, both of which extend slightly from the chassis rather than sitting flush with the watch's curve. This doesn't just look nice – it helps prevent accidental presses, too.

Don't let the elegance fool you, though. The OnePlus Watch 2 is up for rugged activities, with the same MIL-STD-810H durability rating as found on many of the best Garmin watches for outdoor sports. The display is made of tough sapphire crystal, as found on the top-tier Apple Watch Ultra, and it's also IP68 rated, with water pressure resistance of up to 50 metres, so it's safe for swimming.

Another big improvement is that OnePlus has adopted Google's Wear OS software. This means you can say goodbye to the rudimentary functions of the previous edition, and enjoy the familiar Google suite of wearable apps. From my wrist, I could use Google Calendar to check my meeting schedule, Google Maps to get transit directions to a cross-town venue and Google Pay for my Tube fare. You'll find plenty of other third-party apps in the Google Play Store, but the preinstalled ones catered to most of my needs.



OnePlus doesn't position itself as a health company, so I came to the Watch 2 without high expectations for its fitness tracking abilities – but here, too, it's made big advances. The new watch is loaded with sensors and fitness features: I tested the heart-rate monitor and found it pleasingly accurate, while dual-frequency GPS makes sure your movement is monitored precisely at all times.

There's direct support for dozens of sports, centred on an activity-tracking app that makes it easy to monitor your movement (including step count) on a daily basis. Sleep- and stress-tracking apps provide further wellness information that can be reviewed from either your wrist or in the phone-based OHealth app. I prefer to browse Google's fitness metrics via Fitbit, but the OnePlus software also offers advanced insights for selected sports, including running, with vertical amplitude, ground contact time, stride length, cadence, pace and VO2 max all tracked.

The one feature I loved about the original OnePlus Watch was its battery life, and I'm relieved to say the Watch 2 retains that strength. OnePlus claims a full

charge will keep it going for up to two weeks in power saver mode, or up to 100 hours in normal "smart" mode – a huge advantage over the Samsung Galaxy Watch 6 and Google Pixel

Watch 2, which need to be charged almost daily. I squeezed just under three days of use from the Watch 2, during which I called on the GPS a few times a day for Google Maps or tracking workouts.

And when the time comes to recharge, it's super-speedy. With the supplied fast charger the watch can suck up a day's worth of power in only ten minutes, while completely filling the battery takes a single hour. You can also detach the proprietary charging base and use it with any USB-C charger, which is a great convenience when travelling.

While the OnePlus Watch 2 is a major upgrade over the original, it does omit a few key features of its rivals. A major one is fall detection: we've heard multiple reports of this feature saving lives, so any watch focusing on health and fitness should include it. Hopefully it can be added in a later software update.

Another missing feature is 4G connectivity. Most high-end watches offer a cellular variant, which can be registered with its own SIM. You can then leave your phone at home and use the watch to send and receive messages, make payments, search for directions and so forth. The fact that this isn't possible with the OnePlus Watch 2 won't be a deal-breaker for most, but it does prevent you from getting the most out of the wearable format.

Even so, the OnePlus Watch 2 remains a superb device. It fixes everything that was wrong with the original OnePlus Watch, with greatly improved fitness tracking and a solid app suite courtesy of Google's Wear

OS. Even better, it keeps the exceptional battery life of its predecessor, alleviating a pain point that afflicts almost every other smartwatch. OnePlus phone users can be very happy at finally

having a great watch to call their own; frankly, it makes a great companion to any Android phone. **KATE KOZUCH**

ABOVE The OnePlus Watch 2 has a much more stylish look than its predecessor



"The watch is loaded with sensors and fitness features: I tested the heart-rate monitor and found it pleasingly accurate"

LEFT The watch is protected by tough sapphire crystal, and it's IP68 rated too

SPECIFICATIONS

1.43in 466 x 466 AMOLED display • Qualcomm Snapdragon W5 Gen 1 processor • 2GB RAM • 4GB eMMC (OS) • 32GB storage • GPS • NFC • Bluetooth 5 • heart-rate sensor • gyroscope • accelerometer • barometer • SpO2 sensor • geomagnetic sensor • light sensor • barometer • IP68 • 5ATM water resistance • 500mAh battery • Wear OS 4 • supports Android 8 or later • 46.6 x 12.1 x 47mm (WDH) • 49g • 1yr RTB warranty

Withings ScanWatch 2

Battery life of almost a month plus a distraction-free interface make this a great smartwatch

SCORE ★★★★★

PRICE £267 (£320 inc VAT)
from withings.com

The Withings ScanWatch 2 isn't your ordinary wearable. While most smartwatches offer modern, high-tech designs, this one has an elegant, timeless appearance. It's made from stainless steel and topped with sturdy sapphire glass; two illuminated hands sweep around the watch face, while a small analogue dial tracks your step progress. It's comfortable to wear at night, with a fluoroelastomer strap that doesn't dig in, and it comes in white, dark blue and beige face options.

In fact, the only indication that there's more to the ScanWatch 2 is the little black circle on the upper half of the face. Twist the rotating crown, or just raise the watch, and this 0.63in greyscale OLED screen springs to life. By default it shows the time and the date, but you can cycle between other views showing your heart rate, distance covered, breathing exercises, workouts and more.

For sure, it's a more limited experience than you'll get from a "real" smartwatch. The ScanWatch 2 can't pick up calls, respond to notifications, control your music or run apps. But this is by design: it's intended for quietly tracking your activities, with no distractions or interruptions. You can actually check your messages on the watch if you want, but they scroll across the tiny

screen ticker-style, with no way to skip or page ahead – so if it's a long message you could be staring at the display for quite a while. Nor can you answer messages from the watch.

The real magic starts once you get into an actual workout. The Withings ScanWatch 2 monitors your activity with a treasure trove of sensors: as well as tracking your movements, it can measure your respiratory rate and blood oxygen levels, detect abnormal heartbeats, record an ECG and much more.

There's a wide range of supported workout types, including surfing, yoga, pilates and various sports (even padel). Some basic activities are automatically detected; for the rest you must manually tell the watch to begin tracking. This isn't tricky, though, as you can program a long press of the crown to kick off your preferred activity.

There are limitations. If you're a runner, you may find the lack of onboard GPS frustrating: the ScanWatch 2 relies on your phone to map your runs and calculate the distance you've covered, so that's an extra thing you'll need to carry. I also saw a few consistency issues; most of the time the ScanWatch 2 broke down my exercise records into zones such as light, moderate and intense based on oxygen consumption, but sometimes it didn't. It also occasionally mistook car drives and walks for swimming and cycling sessions.

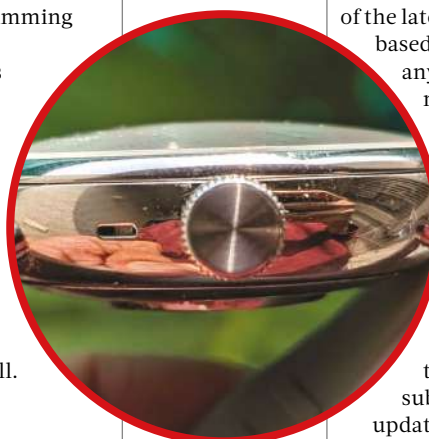
On the plus side, it offers an unusual thermometer function, which detects fluctuations in your baseline skin temperature day and night to let you anticipate fevers. This really works: one evening I noticed the chart rising every couple of hours, and the next morning I woke up feeling ill.

To review your statistics and configure other watch options, you use the Withings companion app for Android or iOS. This is a broad, feature-packed tool, even if it feels over-egged compared to the clean design of the watch itself. For example, half of the landing page is covered in general health articles and other material that you can't hide, requiring you to scroll down to see your own latest stats and measurements.



ABOVE The black circle below the "12" is the only sign that this is a smartwatch

"The real magic starts once you get into a workout. The ScanWatch 2 monitors your activity with a treasure trove of sensors"



ABOVE Twist the rotating crown to wake the OLED screen

LEFT You'll need to take your phone with you if you want to track running routes

Still, I like the approachable way in which Withings presents and contextualises your achievements. The Home tab lets you tap into details of all your major stats and activities, but doesn't overwhelm you with numbers; the Sleep Quality screen, for instance, gives you a simple sleep score based on the number of interruptions you've had in the night, plus the duration, depth and other various factors.

For more health data and goal tracking, you can head into the Measure and Achieve tabs. Here you'll also find

plenty of nudging to subscribe to Withings' £9/month workout plan. I've no objection to the idea of this, but it clogs up the app, and similar training plans are available for free on apps such as Nike Training Club.

The ScanWatch 2's simple feature set doesn't just mean a quieter life: it's brilliant for battery longevity. You can use the watch for almost a month on a single charge; I measured 26 days with all features switched on. The proprietary charger then refills the watch from empty to 100% in two hours, and its neat clamp design ensures the watch won't be knocked out of place while it's plugged in.

If you're looking for a do-it-all digital companion you're better off with an Apple Watch or one of the latest generation of wearables based on Google's Wear OS. But for anyone who solely wants to monitor their health and activity, the ScanWatch 2 is a supremely tasteful solution. It squeezes a whole laundry list of sensors into a compact and tasteful case, and it runs for weeks. My only real complaint is the bloated app; here's hoping this gets streamlined and less subscription-oriented in future updates. **SHUBHAM AGARWAL**

SPECIFICATIONS

Greyscale 0.63in 282ppi OLED display • unspecified processor, RAM, storage and battery • Bluetooth LE • heart-rate sensor • temperature sensor • accelerometer • altimeter • SpO2 sensor • 5ATM water resistance • HealthSense OS 3 • supports Android 9 or later, iOS 15 or later • 38mm: 38.4 x 38.4 x 13.4mm; 42mm: 42 x 42 x 12.9mm • 38mm, 35g; 42mm 49g • 2yr RTB warranty





We round up all the available Chromebook Plus laptops together with the best regular Chromebooks to see which sits top of the pile

CHROMEBOOK PLUS LAPTOPS

It's hard to beat a Chromebook for cost-conscious computing. Chromebooks consistently give you more for your money

than the Windows or macOS competition, while Google's Chromebook Plus initiative (see p81) drives home the point that they're no longer just school and student laptops – they can handle business, content creation and even, via streaming, games. With strong baked-in security and hassle-free updates, they are also easier to set up and maintain.

To prove it, we asked the leading Chromebook manufacturers to send in their latest and greatest Chrome OS devices, focusing on those that meet Google's Chromebook Plus spec.

These are Chromebooks that offer more performance for running applications locally, as opposed to simply running web-based apps. They

also have the screen, features and performance to function as serious business and consumer laptops.

However, we've also pulled in some smaller models that might work in other scenarios, and that demonstrate how wide the range of Chromebooks has become. With new software updates and a stronger ecosystem, there's never been a better time to give Chrome OS a try.

Chromebooks could save you money and open up a whole new way of working. The only question is, which of the 13 on test suits you best?

CONTRIBUTOR:
Stuart Andrews

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	Acer Chromebook Plus 514	RECOMMENDED Acer Chromebook Plus 515	LABS WINNER Acer Chromebook Spin 714	Acer Chromebook Vero 514	Asus Chromebook CR11 Flip	Asus Chromebook Enterprise Flip CB5601
Overall rating	★★★★☆	★★★★☆	★★★★★	★★★★☆	★★★☆☆	★★★★☆

Purchase information

Price of model tested ¹	£291 (£349 inc VAT)	£358 (£429 inc VAT)	£666 (£799 inc VAT)	£667 (£800 inc VAT)	£317 (£380 inc VAT)	£666 (£799 inc VAT)
Supplier	very.co.uk	currys.co.uk	currys.co.uk	store.acer.com/en-gb	asus.com/uk	asus.com/uk
Part code	NX.KP4EK.003	NX.KNUEK.006	NX.KLNEK.002	NX.KAJEK.004	CR1102FGA-MK0087-3Y	CB5601FBA-MC0024
Dimensions (WDH)	319 x 227 x 19.9mm	361 x 238 x 19.9mm	322 x 224 x 18mm	313 x 224 x 20.5mm	294 x 206 x 21mm	358 x 262 x 19mm
Weight	1.5kg	1.7kg	1.4kg	1.4kg	1.5kg	2.2kg

Service and support

Warranty	1yr RTB	1yr RTB	1yr RTB	1yr RTB	1yr RTB	1yr RTB
Manufacturer support rating ²	82%	82%	82%	82%	80%	80%
Manufacturer reliability rating ²	90%	90%	90%	90%	88%	88%

Core components

Processor	AMD Ryzen 3 7320C	Intel Core i5-1235U	Intel Core i5-1335U	Intel Core i7-1255U	Intel N200	Intel Core i5-1235U
Cores	4	10	10	10	4	10
Threads	8	12	12	12	4	12
Max CPU speed	4.1GHz	4.4GHz	4.6GHz	4.7GHz	3.7GHz	4.4GHz
Supplied RAM	8GB	8GB	8GB	8GB	8GB	8GB
Empty RAM socket	✗	✗	✗	✗	✗	✗
Primary GPU	AMD Radeon 610M	Intel Iris Xe	Intel Iris Xe	Intel Iris Xe	Intel UHD	Intel Iris Xe

Display

Size and technology	14in IPS	15.6in IPS	14in IPS	14in IPS	11.6in IPS	16in IPS
Resolution	1,920 x 1,200	1,920 x 1,080	1,920 x 1,200	1,920 x 1,080	1,366 x 768	1,920 x 1,200
Pixel density	162ppi	141ppi	162ppi	157ppi	136ppi	141ppi
Frequency	60Hz	60Hz	60Hz	60Hz	60Hz	60Hz
Touchscreen	✗	✗	✗	✗	✓	✓
Glossy or matte?	Matte	Matte	Matte	Matte	Glossy	Glossy

Storage

Model	WD PC SN740	WD PC SN740	Micron 2450	SK Hynix HFM256GD3JX016N	Not specified	WD SN530
Type	NVMe SSD	NVMe SSD	NVMe SSD	NVMe SSD	eMMC	NVMe SSD
Capacity	256GB	256GB	256GB	256GB	64GB	256GB
Empty SSD socket	✗	✗	✗	✗	✗	✗

Battery & charger

Battery capacity	53Wh	56Wh	42Wh	56Wh	50Wh	57Wh
Charger wattage	45W	65W	65W	65W	45W	45W
Charger weight	329g	310g	315g	310g	288g	301g
Charging options	USB-C	USB-C	USB-C	USB-C	USB-C	USB-C

Webcam

Max video resolution	1080p	1080p	1080p	1080p	720p	1080p
Privacy cover	✓	✓	✓	✓	✓	✓

Ports & connectivity

Wireless standard	Wi-Fi 6	Wi-Fi 6E	Wi-Fi 6E	Wi-Fi 6	Wi-Fi 6	Wi-Fi 6E
Bluetooth	Bluetooth 5.1	Bluetooth 5.1	Bluetooth 5.1	Bluetooth 5.2	Bluetooth 5.3	Bluetooth 5.2
RJ-45 speed	✗	✗	✗	✗	✗	✗
HDMI	1.4	1.4	2.1	1.4	✗	2
USB-C	2 x USB 3.2 Gen 2	2 x USB 3.2 Gen 1	2 x Thunderbolt 4	2 x USB 3.2 Gen 2	2 x USB 3.2 Gen 1	2 x USB 3.2 Gen 2
USB-A	1 x USB 3.2 Gen 1	1 x USB 3.2 Gen 1	1 x USB 3.2 Gen 1	1 x USB 3.2 Gen 1	2 x USB 3.2 Gen 1	1 x USB 3.2 Gen 2
MicroSD card reader	✗	✗	✗	✗	✓	✓
3.5mm audio jack	✓	✓	✓	✓	✓	✓

Other features

Backlit keyboard (brightness levels)	✓ (5)	✓ (5)	✓ (5)	✓ (5)	✗	✓ (5)
Touchpad dimensions (WH)	125 x 82mm	125 x 82mm	104 x 65mm	105 x 77mm	97 x 56mm	128 x 73mm
Fingerprint reader	✗	✗	✓	✗	✗	✗
Other accessories	✗	✗	✗	✗	Garaged stylus	✗
Chromebook Plus?	✓	✓	Eligible	Eligible	✗	Eligible

¹Prices are correct at time of going to press but subject to change. ²Based on reader feedback for laptops in the PC Pro Technology Excellence Awards; see issue 351, p28.



RECOMMENDED

Asus Chromebook Plus CM34 Flip

Asus Chromebook Plus CX34

HP Chromebook Plus 15a-nb004na

Lenovo 500e Yoga Chromebook Gen4

Lenovo IdeaPad 5i Gaming Chromebook Plus

Lenovo IdeaPad Flex 5i Chromebook Plus

Lenovo IdeaPad Slim 3i 14 Chromebook



£416 (£499 inc VAT)

£358 (£429 inc VAT)

£233 (£279 inc VAT)

£333 (£400 inc VAT)

£549 (£659 inc VAT)

£333 (£399 inc VAT)

£233 (£280 inc VAT)

very.co.uk

very.co.uk

hp.com/uk

lenovo.com/uk

very.co.uk

currys.co.uk

johnlewis.com

CM3401FFA-LZ0023

CX3402CBA-PQ202

8Y5D1EA#ABU

82W4000JUK

82V80003UK

82T50019UK

83BN001EUK

319 x 235 x 20.7mm

326 x 214 x 18.7mm

362 x 241 x 19.8mm

287 x 208 x 18.9mm

357 x 253 x 19.9mm

316 x 229 x 19.8mm

324 x 216 x 19.3mm

1.9kg

1.4kg

1.7kg

1.3kg

1.9kg

1.6kg

1.5kg

1yr RTB

1yr RTB

1yr RTB

1yr RTB

1yr RTB

1yr RTB

1yr RTB

80%

80%

75%

80%

80%

80%

80%

88%

88%

84%

87%

87%

87%

87%

AMD Ryzen 3 7320C

Intel Core i3-1215U

Intel Core i3-N305

Intel N100

Intel Core i5-1235U

Intel Core i3-1215U

Intel Core i3-N305

4

6

8

4

10

6

8

8

8

8

4

12

8

8

4.1GHz

4.4GHz

3.8GHz

3.4GHz

4.4GHz

4.3GHz

3.8GHz

8GB

8GB

8GB

8GB

8GB

8GB

8GB

✗

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✗

AMD Radeon 610M

Intel UHD

Intel UHD

Intel UHD

Intel Iris Xe

Intel UHD

Intel UHD

14in IPS

14in IPS

15.6in IPS

12.2in IPS

16in IPS

14in IPS

14in IPS

1,920 x 1,200

1,920 x 1,080

1,920 x 1,080

1,920 x 1,200

2,560 x 1,600

1,920 x 1,200

1,920 x 1,080

162ppi

157ppi

141ppi

186ppi

189ppi

162ppi

157ppi

60Hz

60Hz

60Hz

60Hz

120Hz

60Hz

60Hz

✓

✗

✗

✗

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Glossy

Matte

Matte

Glossy

Matte

Glossy

Matte

Kingston OM8PGP4128P

Samsung KLUEG8UHGHC

Samsung KLUDG4UHGCO-BOE1

Not specified

WD PC SN740

Samsung PM-981

Not specified

NVMe SSD

UFS 3.1

UFS 3.1

eMMC

NVMe SSD

NVMe SSD

eMMC

128GB

256GB

128GB

64GB

512GB

256GB

256GB

✗

✗

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63Wh

50Wh

58Wh

47Wh

71Wh

51Wh

56Wh

65W

45W

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65W

45W

45W

65W

325g

288g

312g

359g

340g

340g

350g

USB-C

USB-C

USB-C

USB-C

USB-C

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USB-C

1080p

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Wi-Fi 6

Wi-Fi 6

Wi-Fi 6

Wi-Fi 6E

Wi-Fi 6E

Wi-Fi 6E

Wi-Fi 6E

Bluetooth 5.3

Bluetooth 5.3

Bluetooth 5.3

Bluetooth 5.1

Bluetooth 5.0

Bluetooth 5.1

Bluetooth 5.1

✗

✗

✗

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✗

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✗

2.1

1.4

✗

1.4

✗

✗

1.4

2 x USB 3.2 Gen 1

2 x USB 3.2 Gen 2

2 x USB 3.2 Gen 1

1 x USB 3.2 Gen 1

2 x USB 3.2 Gen 1

1 x USB 3.2 Gen 2, 1x USB 3.2 Gen 1

1 x USB 3.2 Gen 1

1 x USB 3.2 Gen 2

1 x USB 3.2 Gen 1

1 x USB 3.2 Gen 1

2 x USB 3.2 Gen 1

2 x USB 3.2 Gen 1

1 x USB 3.2 Gen 1

2 x USB 3.2 Gen 1

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Making the right Chromebook choice

It used to be so easy to choose a Chromebook: set your budget, see what's available, press Buy. Now, it's a far trickier process

Gone are the days when all Chromebooks were chunky plastic ultraportables with 11in to 13in screens. Now they run the whole gamut of laptops, from slimline 2-in-1 convertibles and detachables to more powerful gaming Chromebooks with RGB lighting and 16in displays.

As with buying any laptop, then, you need to fix your requirements before you buy. Are you going to prioritise portability or focus on models that will be comfortable to work on all day long? Do you need features such as a touchscreen, ruggedisation or a more flexible form factor, or are these irrelevant in comparison to a great keyboard, a big screen and strong performance?

Working out your priorities will help you select the right Chromebook.

■ Go big or go small?

The first decision this will help you make is which screen size to go for. Chromebooks with a 12in to 13.3in screen will generally be thinner and lighter, and more conducive to a 2-in-1 convertible design. On the other hand, they can make it hard to balance legibility with comfort, especially when you're spending hours sitting in front of a browser and a bunch of Google Workspace apps, which is where 15.6in and larger screens come into their own. 14in Chromebooks give you a nice midway point between the two, which is why many manufacturers seem to be standardising on this screen size for their mainstream Chromebook lines.



ABOVE Chromebooks can tackle everyday office tasks with ease

Almost all Chromebooks use IPS technology, with mini-LED and OLED tech pushing prices beyond where most users feel comfortable

Beyond size, you need to think about the screen technology and resolution. Almost all Chromebooks use IPS technology, with mini-LED and OLED tech pushing prices beyond

where most users (and manufacturers) feel comfortable. Full HD resolutions are still the most popular, but to maximise usability many Chromebooks are shifting to a 16:10 aspect

ratio and a 1,920 x 1,200 pixel count. This looks great at screen sizes below 15 to 16 inches, at which point higher resolutions look smoother and sharper, though you'll still find these hard to come by on Chrome OS devices.

Similarly, cheaper Chromebooks often suffer from the same issues as budget Windows laptops: low brightness levels, poor contrast and limited colour gamuts. This Labs is full of Chromebooks that can't show more than 65% of the sRGB colour space, and often less. While that means drabber images, if you're just after a laptop to crunch through spreadsheets then this won't be an

issue. But it will be if you want a Chromebook that can handle more colour-critical creative tasks, such as photo and video editing.

■ Pay for performance?

Two years ago, we saw a plethora of different processor architectures in Chromebooks, with manufacturers experimenting with energy-efficient ARM CPUs as well as using more conventional x86 processors. While these still loiter in some lightweight, cheap or convertible Chromebooks, Intel's technology now dominates the scene. Celeron and Pentium lines have gone the way of the dodo, to be replaced by Intel's far more powerful N-series chips based on its Alder Lake architecture.

These provide enough performance for basic everyday browsing and simple productivity apps, and Chromebooks based on them can feel surprisingly slick and speedy, thanks to the low requirements of Chrome OS. However, we'd still recommend a recent Core i3, Ryzen 5 or Core i5 CPU for good all-round performance and enhanced performance in Android and Linux apps.

Similarly, while you can get away with just 4GB of RAM, 8GB is a must for serious usage, partly because the Chrome browser and many websites



LEFT A few Chromebook models are available with touchscreens

and web-based apps keep growing more demanding. While 16GB can make a difference in a few apps, for most users it won't make a difference and could just be overkill.

■ Don't fall short on storage

Amazingly, we still see some Chromebooks coming through with just 32GB or 64GB of storage, with the excuse that you don't need more if you're only using web-based apps. Again, though, having more will give you extra flexibility to use Android and Linux apps, and the ability to work on local files rather than files stored in the cloud, which is where latency and performance issues tend to creep in, especially when you don't have access to a high-speed network.

This is why Google has mandated 128GB as a minimum for Chromebook Plus models, and why you ought to think about 256GB or more. You should also bear in mind that Google hasn't mandated what type of storage this should be. For the smoothest, fastest experience, stick to Chromebooks using NVMe SSDs or UFS 3.1 storage over the slower, more old-fashioned eMMC flash.

■ Connectivity and comfort

Chromebook manufacturers have a nasty tendency to skimp on connectivity, with even some mid-range Chromebooks sticking to slower USB 3.2 Gen 1 Type-A and Type-C ports; these max out at 5Gbits/sec, while USB 3.2 Gen 2 doubles that to 10Gbits/sec and USB 4 to 40Gbits/sec (minimum). It's also worth having more than one USB-C port to play with, not least because you'll need one to charge the Chromebook for at least some of the time.

You can also use the USB-C port to connect to a screen, but we always still welcome the presence of an HDMI output. You never know when it might come in useful.

Luckily, Wi-Fi 6 has now become the standard for networking on Chromebooks, and a growing number of Chromebooks have introduced Wi-Fi 6E. Bluetooth 5.1 to 5.3 support is also ubiquitous, and wireless mice, keyboards and headsets will work as well on a Chromebook as on a Windows laptop, even if there may be some missing or unused functions or keys.

As with any laptop, don't neglect the ergonomics. A keyboard that annoys you in the early days of

What is Chromebook Plus?

Google has long had problems making the distinction between cheap, low-performance Chromebooks and the more ambitious, premium Chromebooks it's trying to sell to enthusiast users and big business. In October 2023 it launched Chromebook Plus, an initiative designed to address that problem, while also driving home the point that modern Chromebooks can do much more than run a browser.

Manufacturers can employ a new logo while users gain a handful of perks. Meanwhile, developers of Android apps can have more confidence adding Chromebook-friendly UIs and tools, knowing that Chromebook Plus models will have the performance and features to run them at their best.

Minimum requirements for a Chromebook Plus model include an Intel Core i3 or equivalent CPU, 8GB of RAM and 128GB of storage – though this can be eMMC flash memory rather than an NVMe SSD. The display needs a 1080p resolution and IPS or better screen technology, while all Chromebook Plus devices need a 1080p webcam that supports temporal noise-reduction features.

Previous Chromebooks have met most or all of these requirements, and some models are eligible for a Chromebook Plus update, meaning users can expect the same software enhancements and perks. These start with a slightly different setup experience with Chromebook Plus branding, along with an exclusive AI-powered desktop background, with shifts in the lighting as you move from dawn to dusk, plus a matching screensaver. You also get some useful exposure and audio enhancements that work across all video call and meeting apps, not just Google Meet.

Google has sweetened the deal with some Chromebook Plus-exclusive trials or discounts on apps and services, though these are subject to change. And while it's promising further AI enhancements in the future, these have yet to be announced, let alone rolled out.

It's debatable whether Chromebook Plus is a game changer for Chromebooks or a piece of marketing spin, but it's definitely worth opting for a Chromebook Plus model or one eligible for the upgrade. You'll get a great device and some useful extras and, hey, any perk's a perk.

RIGHT A beta version of Steam for Chrome OS makes gaming a possibility



owning a Chromebook may infuriate you for the Chromebook's working lifespan, and while a Bluetooth mouse can help make up for a rough

For the fastest experience, stick to Chromebooks using NVMe SSDs or UFS 3.1 storage over the slower, old-fashioned eMMC flash

and unresponsive trackpad, there may be times when you don't have one to hand.

Webcams and audio setups are also becoming increasingly important, especially when you may end up using your Chromebook for virtual meetings, chats and conference calls. Google has mandated 1080p webcams for Chromebook Plus devices, but even with a common resolution, clarity, colour and exposure control can vary.

BELOW Connectivity options can be limited, so check the specs

■ Services and apps

Chromebooks still work best if you're already embedded in Google's ecosystem, meaning you use an Android smartphone and have access to Google's Workspace apps, either through your company or through a personal account. However, it's far from a walled garden, and you can also use Microsoft's Office apps and services through Microsoft 365, or switch to using Android-based creative and productivity apps.

Google has also worked hard to build partnerships with a number of key software publishers, such as Adobe. In addition, now that the Crostini Linux support layer is baked into Chrome OS, you can also use a wide range of Linux apps.

You still don't get the full range of software you'll find on macOS or Windows platforms, and games can be hard to come by, outside of a small list supported by the Chrome OS beta of Steam. However, that list may grow longer thanks to the improved Linux support for gaming that's being driven by Valve's Steam Deck, and you can always use game-streaming services instead. GeForce Now and Xbox Games Pass Ultimate work a treat on Chrome OS. Similarly, most video- and music-streaming services can be used through their Android or browser-based apps.





ACER CHROMEBOOK PLUS 515

With good performance and a decent screen, the Acer Chromebook Plus 515 is excellent value

SCORE ★★★★★

PRICE £358 (£429 inc VAT)
from currys.co.uk

Acer's large 15.6in screen and corresponding 1.7kg bulk mean that this is not going to be the ideal Chromebook for everybody. With a footprint of 361 x 238mm, it's one of the largest laptops on test – only the HP Chromebook Plus 15a-nb004na and the Lenovo IdeaPad 5i Gaming are bigger – and the chunky 19.9mm profile is hard to ignore. However, if you're looking for a Chromebook for use around the home or office, it has a lot to offer, especially if you're prioritising comfort and good performance at a reasonable price.

As with the smaller Chromebook Plus 514, what looks like an all-metal build turns out to be shiny grey plastic, with the impression enhanced by a faux-brushed aluminium treatment on just under one half of the lid. It's hard to grumble, though, when the construction feels so robust, with no creaking or excessive flex in the body, and only a little creeping in when you apply pressure to the lid. And although the connectivity is fairly basic, with two USB-C 3.2 Gen 1 ports, an HDMI 1.4 output and a single USB-A 3.2 Gen 1 port, it covers most bases, provided that you don't need fast external storage and can live with Wi-Fi 6 rather than Wi-Fi 6E.

What's more, the keyboard is better than you might expect for the price. Sandwiched between the two speaker grilles, it makes up for the lack of a separate number pad with a nice, spacious layout, where the Ctrl, Alt, Shift and Return keys are big enough not to miss when you're typing quickly. There's even



room to separate the cursors out. The keyboard is backlit, too, with five levels of brightness, while the travel and weight of the keys give you plenty of feedback while you work. The touchpad is even better, with a massive 125 x 82mm surface area and a slick, responsive feel courtesy of Acer's recycled plastic that it calls OceanGlass.

True, the display's image quality isn't exceptional.

With a bog-standard 1,920 x 1,080 resolution on a 15.6in screen, you're never going to get the definition and clarity of some of the smaller screens, or the QHD screen on the IdeaPad 5i Gaming.

Within those parameters, though, it's pretty good. We measured brightness at an above average 289cd/m², and though the slightly grey blacks spoil the overall contrast – just 1,056:1 – the screen can still reproduce 65% of the sRGB colour spectrum, where most cheap

ABOVE Acer's Chromebook Plus 515 is one of the biggest laptops on test

Whether you're looking to run productivity apps or experiment with coding, this is a no-nonsense workhorse you can trust

LEFT Build quality is robust, despite the plastic chassis

BELOW The keyboard is spacious, and the touchpad is huge

Chromebooks are stuck at around the 56% to 62% mark.

Sound is another strength, with the DTS-branded audio system dishing out music and soundtracks with some weight and volume, not to mention decent stereo effects. The built-in mic array captures voices clearly, while the 1080p webcam produces mostly well-balanced and exposed video, though it's a little grainy in darker conditions or harsh artificial lighting.

Perhaps the most impressive thing about the Chromebook Plus 515 is that it performs as well as significantly more expensive models, thanks to its Core i5-1335U CPU, 8GB of RAM and 256GB Micron SSD. It was near the top of our score tables in nearly every benchmark, including the most demanding 3D and multitasking tests. It even topped the chart in the Basemark Web 3.0 benchmark, beating the best from Lenovo and Asus, not to mention the Core i7-powered Acer Chromebook Vero 514.

In everyday use it just kept working smoothly, even with 20 browser tabs open, including several Google Workspace apps. Whether you're looking to run productivity apps or experiment with coding or Linux applications, this is a no-nonsense workhorse that you can trust to get things done.

Battery life is limited by the bigger screen – we ran it down in just over nine hours of continuous video playback – but this is a great Chromebook for families, students and business users, providing mobility isn't your main priority.



ACER CHROMEBOOK SPIN 714

A fantastic convertible Chromebook with features that justify the high price

SCORE ★★★★★

PRICE £666 (£799 inc VAT)
from currys.co.uk

For several years, Acer's Chromebook Spin 713 was the premium Chromebook to buy, competing with Google's own Pixelbooks on design, specs and features, while undercutting them on price. The Spin 713 is still available, but it's no longer being updated with Intel's latest CPUs. Luckily, its successor, the Spin 714, is every bit as good.

Sure, it comes without the old model's 3:2 ratio QHD screen, swapping it out for a more standard 14in, 16:10 display with a 1,920 x 1,200 resolution. Otherwise, though, it maintains the same styling and dark grey, all-aluminium build. It's still a 2-in-1 convertible, with a 360° hinge that allows the screen to fold back flat against the base, and work either as a chunky pseudo-tablet or in a tent configuration that's ideal for playing games or streaming video.

The build feels incredibly robust, and comes with MIL-STD 810H certification for durability. With a desktop footprint of 319 x 227mm, a maximum thickness of 19.9mm and a weight of only 1.4kg, it's also one of the most portable 14in Chromebooks.

This doesn't come at the cost of user comfort. The chiclet keyboard takes up most of the width of the device, and has large, flat-topped keys with a light, near-silent action. There's not much click, but plenty of tactile feedback otherwise. At 104 x 65mm the touchpad isn't as large as those on the HP Chromebook Plus 15 or the Asus Chromebook Plus CX34, but it's smooth and sensitive, making it easy to navigate around Chrome OS and web-based apps or make quite precise selections.



PC PRO
LABS WINNER

What's more, Acer has included a garaged USI 2.0 stylus, which slots in and charges in its space near the front-right corner. It supports 4,096 pressure levels plus tilt sensitivity, so it can do more than the basic pens provided with some cheaper models. Even if you stick to notes and sketches rather than digital art, you can create some quite sophisticated results.

The display is a cut above most of the screens on test. There's nothing unusual about the 14in diagonal or 1,920 x 1,200 resolution, but at 390cd/m² it's significantly brighter than most rivals' screens – and punchier, too, thanks to a contrast level of 1,917:1. What's more, colour reproduction is in a different league, covering 92% of the sRGB colour gamut and 70% of DCI-P3, with a respectable average Delta E of 2.1. This makes videos and games look great, and enables you to use this laptop in brighter conditions where many screens in this Labs just wouldn't be visible. Throw in clear sound with a clean mid-range, a hint of bass and a convincing stereo soundstage, and you have a Chromebook that's a real entertainer.

ABOVE The display is one of the best you'll find on a Chromebook

Right now, this is the best Chromebook out there, if not in raw performance then in features, design and bang for buck

LEFT The sturdy build has MIL-STD 810H certification

BELOW Tent mode is ideal for gaming and streaming video

There's more good news on the connectivity front. You get Wi-Fi 6E rather than the standard Wi-Fi 6, and the two USB-C ports support Thunderbolt 4 and DisplayPort as well as USB 3.2 Gen 2. Even the HDMI port is a cut above the rest, supporting HDMI 2.1 for 4K/60fps output.

The Spin 714 is one of the few Chromebooks out there to have progressed beyond Intel's 12th-generation Core CPUs.

Our test version shipped with a Core i5-1335U and 8GB of RAM, and while it has the same two Performance cores and eight Efficiency cores as the Core i5-1235U used elsewhere in this Labs, it also has an extra 200MHz of turbo boost and support for DDR5 RAM. This keeps the Spin 714 in the top four positions across most of our benchmarks, only drifting further down the table in one or two tests. It will easily handle Android apps, Linux apps and even some light Steam gaming.

Finally, battery life is impressive, with the Spin 714 lasting just two minutes shy of the 12-hour mark in our video playback tests.

Right now, this is the best Chromebook out there, if not in raw performance then in features, design and bang for buck. There aren't many better ways you can spend just £799 on a laptop of any kind.





ACER CHROMEBOOK VERO 514

It's getting old and the display could be better, but this is still a powerful and effective Chromebook

SCORE ★★★★★

PRICE £667 (£800 inc VAT)
from store.acer.com/en-gb

Acer's sustainable Chromebook is getting a little long in the tooth – this is its third appearance in *PC Pro* and its second entry in the Labs. Yet it still has the charms that have served it well so far, along with a spec that keeps it in contention. It comes in Intel Core i3, i5 and i7 variants, with different RAM and SSD configurations, but the Core i7 version tested here gives you an extra burst of speed.

The chassis and screen bezel are formed from 30% post-consumer recycled plastics, while the keycaps and speakers are 50% PCR. The OceanGlass touchpad is a glass-like surface made from reclaimed plastic waste, and even the packaging combines recycled card and paper with sustainable natural fibres. To push the point, there's a stamped Post Consumer Recycled logo beneath the keyboard, while the casing eschews the usual faux-metallic finish for a gritty, plain grey texture with white, grey and yellow specs showing through. It feels as tough as it looks, with MIL STD-810H certification for sand, moisture, dust and impact resistance.

It's not ultra-slim, at just over 20mm thick, but at 1.4kg the Chromebook Vero is very manageable as a take-anywhere computer. What's more, the ergonomics are rock solid. The hinge and the bottom of the screen raise the angle of the keyboard deck while the clamshell's open, and the palm rests support your hand in a comfortable typing position.

The touchpad is sizable, at 105 x 77mm, and while it doesn't quite feel like glass it's smooth and accurate. Crucially, the keyboard is excellent, with large, flat keys in a sensible,



ABOVE The lacklustre display detracts from an otherwise powerful laptop

its own, providing clear, well-exposed video in most conditions.

In most Labs group tests a machine that launched in 2022 with a 12th-generation Intel CPU wouldn't make much of an impression, but Chromebooks tend to use older processors than Windows laptops,

and this doesn't seem to hold performance back. With its Core i7-1255U and 8GB of RAM the Chromebook Vero is still the fastest Chromebook in this Labs, holding its

This isn't the flashiest Chromebook out there, but it's one of the most practical, speedy and effective, especially if you're buying for work

own against the best of Asus and Lenovo, not to mention Acer's own Chromebook Spin 714. There's easily scope here not just for web-based applications, but also more resource-hungry Linux and Android apps. Good 3DMark scores demonstrate that it could even run some older games through a local Steam installation, though you're arguably better off streaming newer titles through GeForce Now or Xbox Games Pass.

Even the battery life is respectable. While the Vero 514 didn't quite make the full 12 hours in our HD video playback rundown test, it came close.

This isn't the flashiest Chromebook

out there – and we'd love to see it get an update –

but it's one of the most practical, speedy and effective, especially if you're buying for work. And if you don't need this model's all-out speed, its Intel Core i3 sibling can be found for just £299 at currys.co.uk.

standard layout, good tactile feedback and a quiet but consistent action. If you need a laptop for bashing out text-heavy documents then this one's up to the job, and the keyboard is also backlit with five levels of brightness.

Connectivity is a little better than on some more basic Chromebooks. The two USB-C ports are USB 3.2 Gen 2, giving you 10Gbits/sec bandwidth

for storage where others are stuck with 5Gbits/sec USB 3.2 Gen 1. You also get an HDMI 1.4 port for an external display or projector, along with Bluetooth 5.2 and Wi-Fi 6.

The screen is a little disappointing.

Its brightness level of 277cd/m² puts it a long way behind its Acer stablemate, the Chromebook

Spin 714, when it comes to vibrancy and contrast, and in tests we found it covered just 61% of the sRGB colour gamut and 44% of DCI-P3. Images and text still look crisp at this screen size, but don't expect the punch of the Spin 714 or Lenovo IdeaPad 5i Gaming Chromebook. The audio could also do with some improvement, getting harsh and piercing as you push the volume upwards. It's better for web chats and meetings than streaming video or playing background music. Still, that's where the 1080p webcam comes into



LEFT The gritty, grey chassis is made from 30% post-consumer recycled plastics

BELOW The excellent keyboard has large keys, a sensible layout and a quiet action



ASUS CHROMEBOOK ENTERPRISE FLIP CB5

A beast of a big-screen convertible, with impressive usability and performance

SCORE ★★★★★

PRICE £666 (£799 inc VAT)
from [asus.com/uk](https://www.asus.com/uk)

The Chromebook Enterprise Flip CB5 comes across as both a reinvention of Asus' excellent Chromebook Flip CX5 convertible, and as a premium, supersized version of its CM34 Flip. Like the former, it's a big-screen, 2-in-1 convertible with a metallic shell and a fast Intel Core i5 spec. Like the latter, it's switched to a squarer display with a 16:10 aspect ratio and 1,920 x 1,200 resolution, only here the screen is a massive 16 inches. Using it as a tablet is a slightly bizarre experience and there's no USI stylus for notes and doodles. But it's brilliant used in tent mode for ad hoc presentations or entertainment.

There's a lot to like about this design, including the thin "nano-edge" frame around the display, and the way the hinge pitches the rear of the laptop upwards for a more comfortable working position. Compared to many of the plastic-heavy Chromebooks on test, the materials feel premium and the build extremely solid, with the near-black finish looking exceptionally smart. Like the old Flip CX5, it meets MIL-STD-810H certification for durability.

Connectivity goes beyond the usual basics, with two 10Gbits/sec USB-C 3.2 Gen 2 ports, a single USB-A 3.2 Gen 2 port and an HDMI 2 video output, plus a microSD card slot and headphone socket. The keyboard is one of the best on test, with 1.4mm of travel and a fantastic light but slightly clicky feel. There's little to quibble about with the layout, bar a tiny split left-Shift key and a pint-sized number pad. The touchpad is wider than average, at 128 x 74mm, and although it's precise don't expect the glass coating of the best units.



Let's get the bad stuff about the screen out of the way. Like too many Chromebook displays, colour depth is poor, covering only 59% of the sRGB gamut and 43% of DCI-P3. You might not notice the difference in isolation, but whack up the brightness and put it next to the Acer Chromebook

Spin 714 or the Lenovo IdeaPad 5i Gaming Chromebook Plus and suddenly both stills and video look rather drab. What's more, the 1,920 x 1,200 resolution can look stretched at this screen size,

so this screen doesn't have the same clarity as you'll find on the Lenovo. Yet it's fairly bright, reaching 325cd/m², and low black levels mean plenty of punchy contrast. This and the sheer size work particularly well for video streaming and gaming, though it's also easy on the eyes when you're

ABOVE The screen is large, but don't expect a huge range of vibrant colours

Battery life is stronger than you might expect with such a big screen, with 11hrs 40mins of 1080p video playback in our tests

LEFT Unlike many Chromebooks, the finish feels premium

BELOW Tent mode is ideal for presentations and entertainment

trying to get some work done: there's no need to squint on a screen this big.

There's no need to plug any headphones in, either, at least if you're not out in public, as the Harman Kardon audio system dishes out good sound at sensible volumes, with great mid-range clarity and even some bass. Throw in sensitive mics and a 1080p webcam that produces crisp and well-exposed video, and you've got a fine platform for calls and meetings.

This is one of three laptops on test with the Intel Core i5-1235U processor, and it's an ideal choice for Chromebook use. It provides more than ample performance across web-based and Android apps, plus basic 3D graphics capabilities, without the expense of the more powerful Core i7 CPUs. The Enterprise Flip CX5 came second in many of our benchmarks, just behind the Core i7-powered Acer Chromebook Vero 514. Where it didn't it wasn't far behind, and even the Acer Chromebook Spin 714, with its newer 13th-generation Core i5, couldn't shake it off. What's more, battery life is stronger than you might expect with such a big screen, with 11hrs 40mins of 1080p video playback in our tests.

It's touch and go which is the best of this month's big-screen Chromebooks; the IdeaPad 5i Gaming Chromebook Plus has the better screen and the lower price, but the Asus has the edge on ergonomics and design. Either way, this is an excellent option whether you're buying for business or for home.





ASUS CHROMEBOOK PLUS CX34

Corners have been cut, but this Chromebook Plus laptop provides excellent value for money

SCORE ★★★★★

PRICE £358 (£429 inc VAT)
from [very.co.uk](https://www.very.co.uk)

It doesn't have the flexible form factor of the Lenovo IdeaPad Flex 5 Chromebook Plus or the specifications of the Acer Chromebook Spin 713 or Chromebook Vero 514, but the Asus Chromebook Plus CX34 triumphs when it comes to value for money. For under £450 you can have a 14in Chromebook with good all-round performance, an attractive thin and light design and a very workable 1080p screen. What's more, it frequently turns up on sale with even more attractive discounts, making it a good choice if you want a Chromebook Plus on the cheap.

It isn't hard to spot where Asus has trimmed some corners. The body and lid are both made from plastic, without a hint of fancy aluminium or magnesium alloys to be found, and while the plastics feel sturdy the CX34 can't match the Acer Chromebook Spin 714 or the IdeaPad Flex 5 Chromebook Plus on first impressions.

Connectivity is fine, with a single USB-C port on the left-hand side and another on the right, where it sits next to two USB-A 3.2 Gen 1 ports and an HDMI 1.4 output. However, there's only Wi-Fi 6 rather than 6E, and a 256GB UFS 3.1 drive rather than a faster NVMe SSD.

Yet the Chromebook Plus CX34 also gets a lot of things right. For a start, the keyboard is among the best you'll find on a cheaper Chromebook. The keys are large and well spaced out, with big Shift, Ctrl and Alt keys on the left and wiggle room around the cursor pad. The usual Chrome OS function keys

are prominent without making the layout cramped or awkward, and the action is slightly soft, but otherwise quite positive, with a nice bounce back on actuation. Asus also wins credit for the touchpad. It's large at 128 x 73mm, with a cool, smooth surface and excellent tracking of every swipe, tap and multi-finger gesture.

The screen is average rather than amazing, but you still get brightness levels of 282cd/m² that are good enough for use in anything but direct sunlight, and a better-than-average

contrast level of 1,147:1.

There's not a huge amount of colour depth – only 60% of the sRGB gamut can be reproduced – but it doesn't actually look bad when you're gazing at still images or streaming video. There's a vibrancy and

ABOVE The screen is quite vibrant and punchy for the price

punchiness that some of the screens on cheaper Chromebooks lack. Even the sound holds up well at low to medium volume levels. There's not much warmth or bass, but it's clear and listenable as long as you don't start pushing the volume to Spinal Tap extremes.

The Chromebook Plus CX34 gets a lot of things right. For a start, the keyboard is among the best you'll find in a cheaper Chromebook

When it comes to performance, here you have a Core i3-1215U processor rather than the Core i5 and Core i7 CPUs found elsewhere, but the Chromebook Plus

CX34 still finds a place in the top half of our benchmark table in all our tests, sometimes placing one or two positions above that. It's a solid all-rounder, performing well both in web-based application benchmarks in WebXPRT 4 as well as 3D benchmarks and even our harsh multitasking test. With just two Performance cores and four Efficiency cores, the Core i3 is no powerhouse, yet it holds its own against a range of CPUs.

LEFT The Chromebook Plus CX34 has an attractive design

BELOW The keyboard is superb for a budget Chromebook

As for battery life, the Chromebook Plus CX34 doesn't excel in this competition, surviving a little under 11 hours in our 1080p video rundown test. Yet even this puts it in the company of some more expensive Chromebooks, and can't be considered a bad result.

It won't convince you that it's a premium Chromebook, but the 1.4kg Chromebook Plus CX34 comes across as a competent and likeable mid-ranger. If you're short on cash and in need of something super-portable, it's definitely worth a look.



LENOVO IDEAPAD FLEX 5i CHROMEBOOK PLUS

The IdeaPad Flex 5i is a strong cost-conscious option with good performance for the price

SCORE ★★★★★

PRICE £333 (£399 inc VAT)
from currys.co.uk

If you can't quite stretch to the Acer Chromebook Spin 714, take a good look at the Lenovo IdeaPad Flex 5i Chromebook Plus. Like Acer's premium option, it's a 2-in-1 convertible Chromebook with a 14in, 16:10 aspect ratio display. It has a 12th generation Intel Core i3 CPU rather than the Acer's 13th gen Core i5, but it's fairly strong on features overall. And where the Acer will cost you close to £800, the Lenovo can be found for under £400 (although its price can sometimes jump to £449). That makes it one of the best-value propositions in this Labs.

You don't get quite the same experience. Where the Spin 714 has a gorgeous all-aluminium construction, the Flex 5i makes do with a primarily plastic body and an aluminium alloy lid. The build still feels extremely solid, however, and the lid has an interesting two-tone effect, while the finish on the body carries on the same blue metallic shade. At 1.6kg, the Lenovo is heavier, but not uncomfortably so, and the thin screen bezel and sculpted body do a fine job of minimising bulk. It's too big and heavy to see much use in tablet format, but works extremely well in the standard clamshell mode or the touchscreen tent mode, where it comes into its own for Netflix binges or streaming games.

There's not as much travel as on some Lenovo keyboards, but the keys have a fast, lightweight action that's ideal for text-heavy productivity work. It helps that the layout plays things straight, with no weird, undersized function keys and everything where you might expect it. Lenovo has also made the most of the space available by fitting a larger than average 119 x 75mm touchpad. It's



smooth and slightly cool to the touch, and makes taps, swipes and multifunction gestures a breeze.

The Flex 5i Chromebook Plus offers better connectivity than Lenovo's cheaper Chromebook models, with one fast USB-C 3.2 Gen 2 port as well as a slower USB 3.2 Gen 1 variant, along with a USB-A 3.2 Gen 1 port, a microSD card slot and a headphone socket. The only thing missing is an HDMI output, leaving you dependent on

a USB-C dock or DisplayPort adapter if you want to hook up an external monitor.

You might not need to, as the screen you have is very capable. Brightness is close to 300 nits at 296cd/m², while the 1,201:1 contrast ratio is also above the average for mid-range Chromebooks. We'd like to see a stronger grasp of colour – sRGB coverage is only 58% – and it's interesting that Lenovo sells a similar model, the IdeaPad Flex 5i Chromebook Gen 7, promising a 400cd/m² screen and 100% sRGB. Given that the two seem virtually identical, it could be worth seeking out.

Otherwise, it's hard to spot faults. The MaxxAudio audio system concealed beneath the grilles to the left and right of the keyboard

ABOVE The decent screen and excellent keyboard belie the Flex 5i's low price

delivers a richer and more immersive sound than most Chromebooks on test, with clearer positioning of stereo and pseudo-surround effects. Video from the 1080p webcam can look slightly overexposed, but there's

plenty of detail and little noise, even in gloomier conditions. Throw in Wi-Fi 6E networking, and the Flex 5i Chromebook Plus is perfectly equipped to handle video chat and conferencing duties,

especially with the AI enhancements that come with Chromebook Plus.

As for performance, the Flex 5i Chromebook Plus isn't far behind the fastest Chromebooks in this Labs, despite having a slower Intel Core i3-1215U CPU. It isn't too far behind the Acer Chromebook Plus 515, which has a 10-core Intel Core i5-1235U to work with, and is only soundly beaten by the Acer Chromebook Spin 713 and Chromebook Vero 514, with their newer or superior CPUs. Only in the 3D benchmarks does it fall significantly behind the leaders, but

as native 3D gaming isn't a Chromebook strength, this shouldn't be a dealbreaker.

With good all-round performance, a strong screen and reasonable stamina – lasting for over nine-and-a-half hours in our battery tests – this is a cost-conscious Chromebook that punches well above its weight.

The Flex 5i is well equipped to handle video chat duties, especially with the AI enhancements that come with Chromebook Plus

LEFT Although the body is plastic, build quality is strong

BELOW The thin bezel and sculpted body help to minimise bulk





LENOVO IDEAPAD 5i GAMING CHROMEBOOK PLUS

This is the best of the big-screen Chromebooks, with gaming features and a great display

SCORE ★★★★★

PRICE £549 (£659 inc VAT)
from very.co.uk

Google's attempts to push Chromebooks as gaming devices have mostly been disastrous. In the wake of the demise of its own Stadia cloud gaming service, Chromebook users have had to rely on Xbox Games Pass Ultimate and Nvidia's GeForce Now if they wanted to play games. Yet Google's initiatives have had one upside: the emergence of some gaming-focused, premium Chromebooks that turned out to be just as good for everything else. The Lenovo IdeaPad 5i Gaming Chromebook Plus is a case in point.

Let's start with the screen. Where most previous big-screen Chromebooks have fielded 15.6in, 1080p displays, the IdeaPad 5i Gaming Chromebook Plus has gone bigger, with a 16:10 aspect ratio 16in screen, and a higher resolution, at 2,560 x 1,600. What's more, it has a 120Hz refresh rate. Add the 393cd/m² brightness levels, 97% sRGB coverage, 70% DCI-P3 coverage and excellent colour accuracy, and you have the best display of any Chromebook in this test. It's fantastic for working across multiple windows or streaming 4K video, and brilliant if you splash out on the Ultimate tier of GeForce Now, where you can stream at the native resolution and the maximum refresh rate (bandwidth permitting).

As for the design, it bears similarities to Lenovo's IdeaPad Flex 5i Chromebook Plus, but the blue finish and metallic lid are enhanced with a patterned area on the surface of the latter and an RGB backlit keyboard



when you open the clamshell up. You can set up flat colours or a rainbow effect, set the keyboard to take its tones from your current Chrome OS colour scheme, or customise the colours across four zones, spreading left to right. There are no per-key customisation options or animations, but you can still get some fun effects.

The keys themselves are a massive plus point. They're designed to appeal to gamers, with 1.5mm of travel, anti-ghosting features and a clicky feel, but this actually makes the keyboard great for typing, too, despite a little extra bounce in the middle of the pad. And while most gamers will reach for a mouse, the touchpad is perfectly usable for everyday browsing and productivity work, with a cool, smooth surface and a generous 120 x 76mm area to work with.

In most other respects, this is a top-notch Chromebook. It's missing the USB-C 3.2 Gen 2 port of the IdeaPad Flex 5i Chromebook Plus, but you still get a USB-C 3.2 Gen 1 port

ABOVE The large, bright and colour-accurate 16in screen is the best in this Labs

We didn't have high hopes for its battery life, but it surprised us by lasting for over 11 hours in our HD video playback test

LEFT The blue metallic lid provides an eye-catching look

BELOW The RGB backlit keyboard is another striking design flourish

and one matching USB-A port on each side, along with a microSD card slot and a headphone socket. Just be aware that you'll need a dock or DisplayPort adapter if you want to connect to an external display or projector. You've also got Wi-Fi 6E for fast networking and stable game streaming, plus a MaxxAudio speaker system that can handle the demands of action games and blockbuster movies and series. It's harsh and rough on the ears at higher volumes, but beefy and immersive if you keep levels low.

With no dedicated graphics chip, the IdeaPad 5i Chromebook Gaming Plus was never going to be a standalone gaming powerhouse. You can install the Chrome OS beta of Steam on it, but you'll only get playable frame rates on older or less demanding games. In all other respects, however, it performs well, with its Core i5-1235U and 8GB of RAM powering it to the top three or four positions across our benchmark tests. In fact, it only falls behind the Acer Chromebook Spin 713 (with its newer 13th gen Intel architecture), the similarly specced Asus Chromebook Enterprise Flip CB5 and the Core i7-powered Chromebook Vero 514. And while we didn't have high hopes for its battery life – just look at that bright 16in QHD-plus screen – it surprised us by lasting for over 11 hours in our HD video playback test. It might be sold as a gaming Chromebook, but this iteration of the IdeaPad 5i is one that could handle a lengthy working day.



Chromebooks can do it!

If you still think that Chromebooks are only good for browsing the web, then may we humbly suggest you update your settings?

Many potential buyers get put off by talk of limitations that applied in the early days of Chromebooks, but which no longer hold true. Sure, a Chromebook won't run the same range of creative design or productivity apps as a Windows laptop or a MacBook, while your native games library is restricted to browser-based titles and controller-friendly Android apps. Yet there are fine alternatives that cover most people's needs, and many work extremely well on Chrome OS.

■ Edit photos

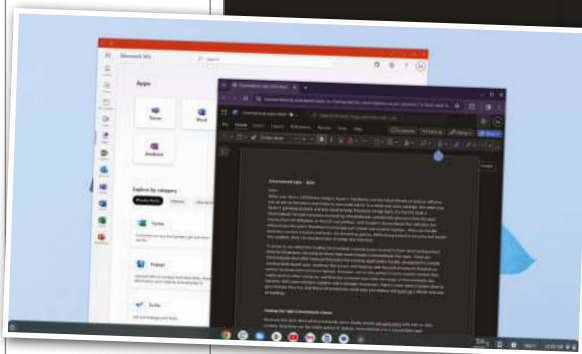
Editing photos on a Chromebook used to mean using a web-based image editor. You now have a range of options. Adobe offers Photoshop on the web to Chromebook Plus users; a streamlined version, with some features stripped out, but others such as layers, quick actions and the new Generative Expand and Fill features remain. Three months of use is bundled as a perk for Chromebook Plus users, along with a three-month subscription to Adobe Express Premium.

Alternatively, Chrome OS's ability to run Android apps opens up other choices. Polar, Pixlr and Snapseed all run well on Chromebooks. Also remember that Chromebooks can run most Linux apps in a Linux container via the Crostini compatibility layer. This is easily enabled from the Developer section of the Chrome OS Settings, so if you want to run GIMP, Krita or Lightbox, you're in business.

■ Edit videos

Chromebooks have traditionally struggled at video editing, with working on large video assets in the cloud a challenge. However, that's changed with the arrival of LumaFusion on Android, with Chrome OS support. LumaFusion provides a familiar and effective desktop UI on Chromebooks, along with powerful multitrack audio and video composition and rendering abilities. If you've used other mainstream video editors, you'll feel right at home. What's more, Google currently offers a 25% discount on purchases for Chromebook users through the Google Play store as part of its perks programme.

RIGHT LumaFusion offers powerful video editing capabilities



ABOVE Microsoft 365 apps work perfectly well on a Chromebook



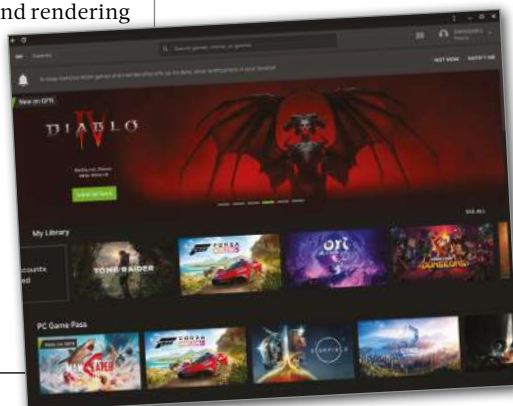
■ Play games

Native gaming on Chromebooks is virtually non-existent beyond simple, browser-based games. Most Android games will run on touchscreen Chromebooks, but few offer keyboard and mouse support. A beta version of Steam for Chrome OS will run on most new Intel and AMD hardware, but it has a limited list of titles.

However, there is a better way to play your favourite games. GeForce Now supports streaming at 1080p on Chromebooks on the cheaper Priority tier, and at up to 4K resolutions with 120Hz refresh rates on the Ultimate tier, though you'll need at least 45Mbps/sec of bandwidth on your internet connection to make it work. It's a brilliant way to play PC games such as *Assassin's Creed: Mirage*, *Starfield*, *Alan Wake 2* and the mighty *Baldur's Gate 3*, with full controller or mouse and keyboard support.

Xbox Games Pass users aren't shut out, either. Subscribers to Games Pass Ultimate can stream to Chromebooks as well as PCs, phones and tablets, and while resolutions are limited to 1080p, you get impressive visual quality and smooth play, bandwidth permitting. Xbox controllers work great with

BELOW GeForce Now supports streaming at up to 4K resolutions on Chromebooks



Chromebooks, too, or you can make the most of any discarded Google Stadia pads you have hanging around.

■ Get work done

For obvious reasons, Chromebooks work best if you or your business has signed up for Google's Workspace services.

The Docs, Sheets and Slides apps have evolved into powerful alternatives to Word, Excel and PowerPoint, while the whole ecosystem does a fantastic job of supporting collaboration within teams and across departments. The real-time collaborative editing features arguably trump Microsoft Office, and working with standard Office documents is now fairly seamless, even supporting comments and revisions.

You're not limited to Workspace, either. You can use the Microsoft 365 Word, Excel, PowerPoint, OneNote, OneDrive and Outlook web apps on a Chromebook, and they'll work fine to open files you store locally or – preferably – files stored on SharePoint or OneDrive. Meanwhile, you'll find a range of Android productivity apps on the Google Play store, or you can switch to LibreOffice through Crostini. Meanwhile, essential productivity services such as Slack, Monday, Trello and Zoom will work as well in the Chrome browser on a Chromebook as they will on the Edge browser on Windows. After all, they're what Chrome OS was built for.

■ Code

There's a reason why the Crostini option can be found in the Developer settings; Linux compatibility was originally added to make developing for and on Chrome OS less challenging and more appealing. As a result, you can now code on Chromebooks using a large selection of languages and Linux development tools, including Visual Studio Code, Android Studio, Docker, Jupyter Notebook and IDLE. Performance wasn't always brilliant on older Chromebook models, but you shouldn't have any issues with modern Core i3, i5 and i7 machines.



ACER CHROMEBOOK PLUS 514

A solid 14in Chromebook, but the screen and performance let it down

SCORE ★★☆☆☆

PRICE £291 (£349 inc VAT)
from [very.co.uk](https://www.very.co.uk)

With its 14in, 16:10 screen and 1.5kg body, the smaller of Acer's Chromebook Plus 51x models offers a cost-conscious alternative to the Acer Chromebook Spin 714 and the Lenovo IdeaPad Flex 5i Chromebook Plus.

Up close, it loses a little of that appeal thanks to its all-plastic construction, but the faux-metallic finish looks good, the construction feels solid and it's easy to lug around. What's more, with two USB-C ports (albeit 5Gbps/sec), a single USB-A port and HDMI 1.4 video output, connectivity is a cut above some cheaper options.



You also get a backlit keyboard that makes up for a soft action with a comfortable and spacious layout, while Acer's OceanGlass touchpad is both smooth and responsive.

Cost savings never come without at least one compromise somewhere, and the Chromebook Plus 514 has two. The first is the screen. The 14in size and 1,920 x 1,200 resolution help ensure

ABOVE The 14in screen is dull and not particularly vibrant



RIGHT The faux-metallic finish looks good and the build feels solid

that text looks smooth and the image stays crisp and clear, but the peak brightness level – a miserly 259cd/m² – is one of the lowest on test, making this one of the dimmer, less vibrant panels on test. It can reproduce 64% of the sRGB colour gamut, which beats the average at this price, but if you're looking for a laptop with a punchy display, this isn't it.

Meanwhile, performance from the Ryzen 3 7320C processor and 8GB of RAM is distinctly under par, leaving the Chromebook Plus 514 sitting in the bottom half of the results table in most of our benchmarks, behind Intel Core i3- and Core i5-powered rivals such as the IdeaPad Flex and the Asus Chromebook Plus CX34. In 3D benchmarks, where we hoped for some grunt from AMD's integrated RDNA 2 GPU, we found the Chromebook Plus 514 trailing the pack. Battery life is more competitive, with the smaller Acer lasting 9hrs 48mins in our 1080p video rundown test.

All in all, this is a decent, slim and lightweight Chromebook on a budget, but it's outperformed by the Asus Chromebook Plus CX34 and outclassed by the pricier models from Acer and Lenovo.

ASUS CHROMEBOOK CR11 FLIP

The low-res screen and poor performance spoil an otherwise fine rugged model

SCORE ★★☆☆☆

PRICE £317 (£380 inc VAT)
from [asus.com/uk](https://www.asus.com/uk)

Like the Lenovo 500e Yoga Chromebook, the Asus Chromebook CR11 Flip is a rugged 2-in-1 convertible sold mostly into the education market. However, the laptop feels like it belongs to an earlier era. At 209 x 206mm, it has a larger desktop footprint, and its 21mm thickness makes it feel bulkier when closed. Most seriously, it has the space for a 13.3in screen, but instead has a much smaller 11.6in display, floating within a massive frame that's nearly an inch deep at the top and bottom. Whether you're using it in laptop, tablet or tent mode, the CR11 looks and feels old-school in all the wrong ways.



To balance that, it feels incredibly tough, with rubber bumpers, splash-proof keys, a scratch-resistant body and shock-proofing to handle 120cm drops. It also has a secondary 8MP camera above the keyboard, for shooting snaps and video while in tablet mode. You can also pair the touchscreen with a garaged USI stylus that's fine for sketches, annotations and making notes. These extras are perfect for school use, but could also work for anyone who spends a lot of time working in the field.

The keyboard isn't as good as the Lenovo's; the feel is light but crisp, but

ABOVE The 11.6in screen is almost lost among the thick bezels

BELOW The CR11 Flip is a rugged 2-in-1 convertible



there's some wobble on the keycaps. Meanwhile, the screen remains a problem. Not only is it dinky, but the 1,366 x 768 resolution gives text and images a fuzzy or pixellated look. The gloss screen helps boost contrast, but brightness is on the low side at 262cd/m², while the greyish blacks can make visibility tricky if you're looking at darker pictures or scenes. Not great for outdoor use.

Audio isn't brilliant, either; the speakers go loud but are also hideously shrill. What's more, while the secondary camera produces surprisingly strong and well-exposed stills and video, the 720p webcam is comfortably the weakest on test, fudging detail and struggling in poor lighting.

The Asus does hold one ace over its Lenovo rival: a stronger spec with the slightly faster Intel N200 processor and 8GB of RAM. This makes it faster in some of our benchmarks, particularly those that demand more in terms of multithreaded performance. All the same, it trails the other Chromebooks on test without matching the Lenovo on screen quality or design. If you want a rugged, compact Chromebook, the 500e Yoga Chromebook is a better bet.

ASUS CHROMEBOOK PLUS CM34 FLIP

Stylish with a strong set of features, but performance is disappointing

SCORE ★★☆☆

PRICE £416 (£499 inc VAT)
from very.co.uk

The Asus Chromebook Plus CM34 Flip makes a striking first impression. Its body might be plastic rather than the aluminium it appears to be, but the Zinc finish looks impressive and, with its squarer 16:10 screen, it brings back memories of Google's classic Pixelbooks and Acer's much-loved Chromebook Spin 713. Like them, it's a 2-in-1 convertible, where the screen can fold back flat against the base to work in a tablet format, or in a screen-first tent configuration in between. Build-quality is excellent. It looks and feels like a premium device.

Asus has also got the practicalities right. You'll find USB-C 3.2 Gen 1 port

on each side of the laptop, along with a single USB-A 3.2 Gen 2 port, a microSD card slot and an HDMI 2.1 video output. Physical power and volume controls plus a headphone socket complete the lineup. The backlit keyboard has an effective layout and a quiet but responsive typing action, and the touchpad is smooth and highly usable. Again, you feel like you're getting a high-end Chromebook at a mid-range price.

The screen carries on the good work. The 14in size and 1,920 x 1,200 resolution give you the same definition and

ABOVE The CM34 Flip has a decent display and stellar battery life

BELOW This 2-in-1 convertible feels like a premium device



detail you'll find on the Acer Chromebook Spin 714 or the Lenovo IdeaPad Flex 5i Chromebook Plus. Brightness is above average at 308cd/m², and there are decent levels of contrast. Colour reproduction could be better, with only 57% of the sRGB gamut covered, but that doesn't seriously impact your enjoyment of streaming video or everyday browsing. It's only when you're editing video or adjusting photos that you might need better colour accuracy and depth.

Battery life is stellar; the CM34 lasted nearly 14 hours in our video rundown test. Unfortunately, performance doesn't measure up. Like the Acer Chromebook Plus 514, the CM34 Flip is based on the AMD Ryzen 3 7320C, and while it has four cores running eight threads at speeds up to 4.1GHz, its dated Zen 2 architecture struggles to keep up with the faster Core i3, i5 and i7 devices on test. We had more hope for the integrated RDNA 2 GPU in our 3D graphics tests, but even here the CM34 Flip fell short with some of the lowest scores in the Labs.

Don't rule out this Chromebook – it has a lot to recommend it – but if you need more than everyday performance, look elsewhere.

HP CHROMEBOOK PLUS 15A-NB004NA

A mediocre display and performance leave the HP trailing big-screen rivals

SCORE ★★☆☆

PRICE £233 (£279 inc VAT)
from hp.com/uk

Big-screen Chromebooks are in relatively short supply, but the HP Chromebook Plus 15a gives you a 15.6in, 1080p display and Chromebook Plus specs at a great price. Officially it costs £450, but the £279 here is what we typically saw in HP's promotions.

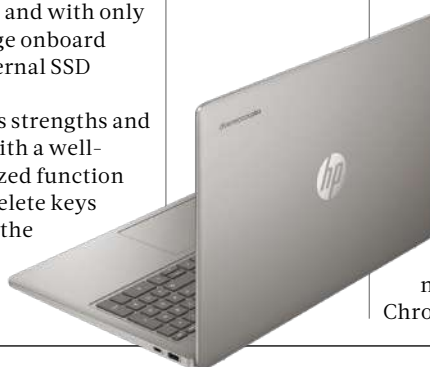
Needless to say, you don't get this screen and spec without some cost-cutting measures. Despite the silver finish, the body and lid are completely plastic, and while the former feels solid there's more give in the latter than we'd like. The lineup of ports and sockets is respectable, though, with two USB-C 3.2 Gen 1 ports, an SD card slot, a 3.5mm

audio socket and a single USB-A port. The Type-C ports support DisplayPort 1.4, but are limited to 5Gbits/sec bandwidth, and with only 128GB of UFS 3.2 storage onboard you might need an external SSD sooner than you'd like.

The keyboard has its strengths and weaknesses. It's big, with a well-spaced layout, good-sized function keys, navigation and delete keys and a number pad. Yet the

ABOVE The screen, keyboard and trackpad are all huge

RIGHT The body and lid are made of plastic



feel is slightly mushy and there's wobble in the keytops as you type. The touchpad, however, is a massive 124 x 80mm, and while its plastic coating isn't as smooth as glass rivals, it's still responsive.

The screen is exactly what you'd expect from a cheap 15.6in laptop. With a maximum brightness of 266cd/m², it's bright enough in a darkened room but struggles in sunlight or bright lighting, and while the contrast is actually above average, the image is subdued due to a lack of colour coverage. Sound is tinny at all but the lowest volume levels, but HP wins points for the 1080p webcam, which captures crisp and well-exposed video in most situations.

The Chromebook Plus 15a has the same Intel Core N305 and 8GB RAM core spec as the Lenovo IdeaPad Slim 3i, but due to better (if noisier) cooling and faster storage, it scored higher across our benchmarks, even turning up in the top half of the table in some tests. Buy it cheap, and the Plus 15a is a solid and inexpensive Chromebook for browsing, family use and study – but it's not in the same league as the Acer Chromebook Plus 515.

LENOVO 500E YOGA CHROMEBOOK GEN 4

Forgive the poor performance and this is a capable and rugged laptop

SCORE ★★☆☆

PRICE £333 (£400 inc VAT)
from lenovo.com/uk

If you're looking for a tough, flexible and highly portable Chromebook, the Lenovo 500e Yoga could be perfect. It's a ruggedised 2-in-1 with a distinctive 12.2in, 16:10 screen, and it goes beyond the usual MIL-SPEC-810H standard for dust- and shock-proofing by meeting Lenovo's DuraSpec standard for school laptops. That means chunky bumpers, reinforced ports, a robust plastic case and spill-resistant keyboard. If it can withstand life in a primary school, it will definitely handle life around the home or office.

Thanks to the squarer aspect ratio, the design works brilliantly across laptop, tablet and tent configurations.



The keyboard is also better than on some full-sized Chromebooks, with a light but clicky action that's consistent across the whole width and depth. There's just a single USB-C port, which will be in use some of the time for charging, but you get two USB-A ports, a 3.5mm audio socket and an HDMI 1.4 output, plus Wi-Fi 6E.

RIGHT The design works brilliantly in laptop, tablet and tent modes

ABOVE The 1,920 x 1,200 screen provides a pin-sharp picture



The combination of a 12.2in diagonal and 1,920 x 1,200 resolution makes for a pin-sharp picture, while the glossy surface and 282cd/m² brightness levels produce a respectably vibrant image with strong contrast. sRGB coverage, at 66%, is also a little better than the norm. The 1080p webcam delivers sharp, well-balanced images, and while the speakers suffer from a muddled and congested mid-range, there's at least a little body to the output.

In fact, there's one lone area where the 500e Yoga Chromebook falls short. The Intel N100 CPU has only four cores running four threads at a maximum 3.4GHz, and that makes this one of the slower Chromebooks out there. What's more, Lenovo sent us the version with just 4GB of RAM, hobbling its efforts in our more demanding tests. In practice, we found it difficult to find this spec for sale and the price above is for the 8GB variant, which would benchmark slightly faster. All the same, you're getting a Chromebook that's fine for light browsing and business use, but that's going to struggle if you're more ambitious. For some users, that won't be a nightmare – and they'll at least get the benefits of the 500e's 11-hour battery life.

LENOVO IDEAPAD SLIM 3i CHROMEBOOK

An interesting if chunky ultraportable, but performance isn't great

SCORE ★★☆☆

PRICE £233 (£280 inc VAT)
from johnlewis.com

Weirdly, the IdeaPad Slim 3i Chromebook isn't particularly slim, with a 19.3mm thickness that makes it no less chunky than most other Chromebooks on test. What it is, though, is unusually compact, thanks to a shallow 216mm depth that shaves a centimetre or two from the footprint of a typical 14in device. Combine that with a 1.5kg weight, and it's a good option for slinging in the laptop pocket of a backpack and carrying for a day of work or study, especially where conditions might be cramped.

The body is made from plastic, but the aluminium lid and good build



quality mean that it feels robust. Lenovo might have put more thought into the connectivity, however. It's fantastic to have Wi-Fi 6E on such an inexpensive Chromebook, but having one single USB-C port is a problem on a device that uses USB-C for charging; this practically forces you to buy a dock, even with two USB-A ports and an HDMI 1.4 output already onboard.

The keyboard underwhelms, with medium-sized flat keys that have plenty of travel but a spongy action in places. The left

ABOVE The compact IdeaPad Slim is ideal for a student backpack

BELOW The aluminium lid helps it feel robust



Ctrl, Alt and Shift keys, along with the right Shift, Return and Backspace, have been super-sized to make them easier to whack, but the touchpad gets less space than usual. While its tracking is accurate, it's hard to navigate the screen at speed without ramping the sensitivity right up.

To compensate, the display is excellent for the price, reaching 327cd/m² in brightness with a contrast ratio of 1,613:1. For browsing, productivity and even casual video streaming purposes, you might not even notice its limited 62% coverage of the sRGB gamut.

The biggest issue here, though, is performance. While nominally an Intel Core i3 chip, the N305 is based entirely on eight Alder Lake Efficiency cores, running at a maximum of 3.8GHz, and the Slim 3i couldn't even keep up with the similarly specced HP Chromebook Plus 15a. Both use 8GB of RAM, but the IdeaPad Slim 3i lacks the HP's faster UFS 3.1 drive, falling back on the older, slower eMMC.

It doesn't feel slow in everyday use, and the battery life – just shy of 11 hours – is impressive, but this is a good, cheap Chromebook with some irritating faults, rather than a great one.



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How we test

Our regular benchmarks don't run on Chrome OS devices, so we put each Chromebook through a battery of benchmarks that simulate performance in web-based applications along with synthetic tests.

Geekbench 6 falls into the latter category. We use the Android app version of this excellent cross-platform benchmark, which pushes the CPU inside each Chromebook to its maximum, particularly in the multicore test.

WebXPRT, Basemark and JetStream are all web-based benchmarks, giving you an indication of how the Chromebooks will perform when faced with more demanding websites.

We test multitasking by playing a 4K video while running Basemark and Jetstream. The figures you see are the Jetstream scores under these harsh conditions.

We use GFXBench, Geekbench Compute and 3DMark Mobile to assess the GPU's performance in Android apps. The latter two benchmarks are synthetic, while GFXBench uses a dummy game to produce frame rates. Although we test on-screen and off-screen performance, we only print the off-screen results here for a fairer comparison.

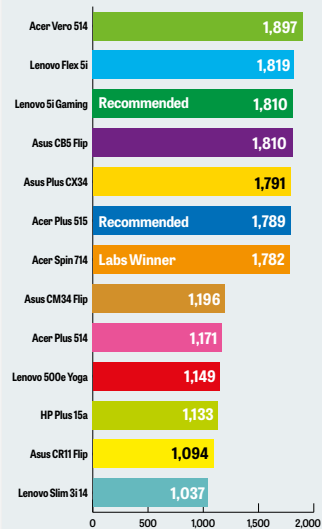
We also check screen quality, brightness and contrast using a colorimeter. The higher the colour coverage the better, while ideally we're looking for an average Delta-E under 1 to indicate near-perfect colour accuracy.

Our final objective test runs down the battery while looping a 1080p video file at 150cd/m² screen brightness.

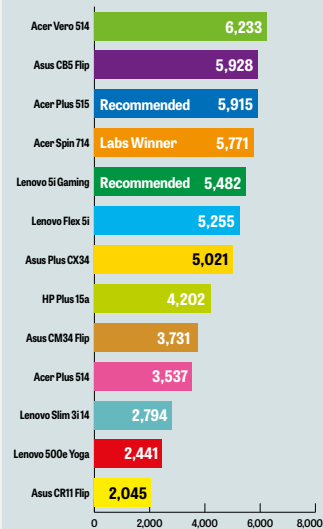
Beyond these tests, we also use each Chromebook across a range of scenarios, including light office work, streaming music and video and streaming games from Xbox Games Pass Ultimate and GeForce Now, in order to see how the screen, keyboard, trackpad and audio system hold up in real-world use.

Speed tests

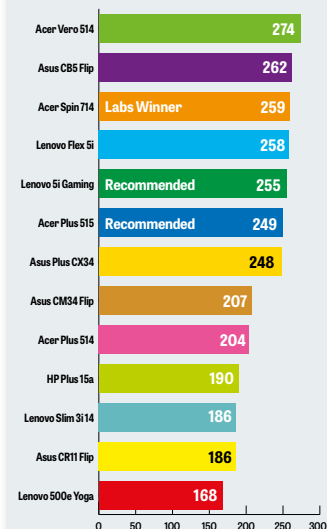
Geekbench single-core



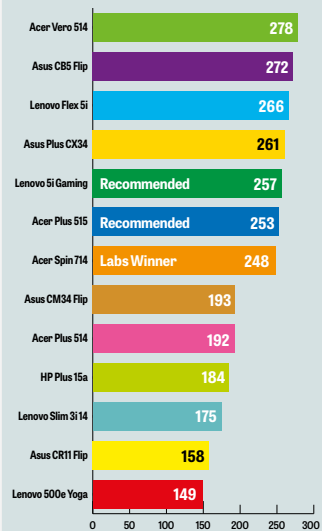
Geekbench multicore



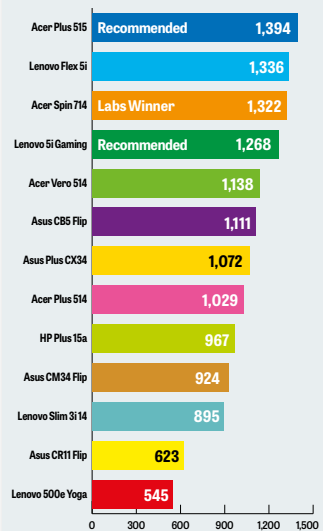
WebXPRT 4



JetStream 2.1

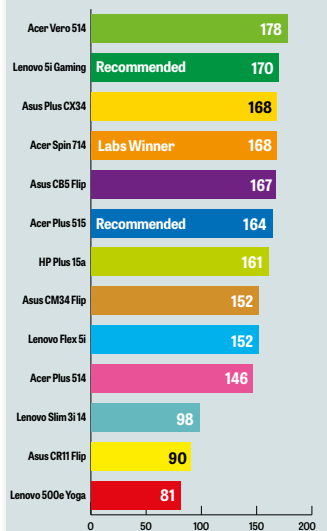


Basemark Web 3



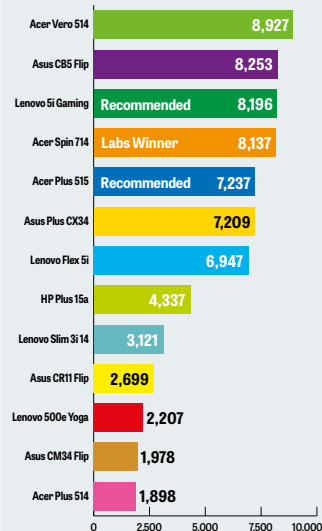
Multitasking

(Jetstream 2.1 score)



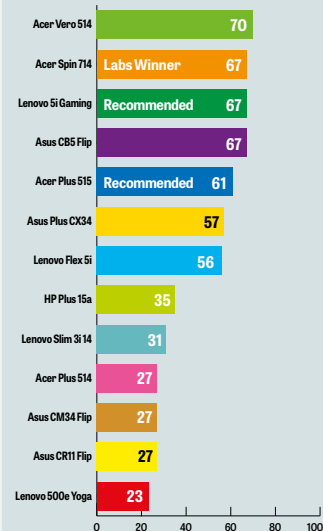
3D tests

3DMark Wild Life

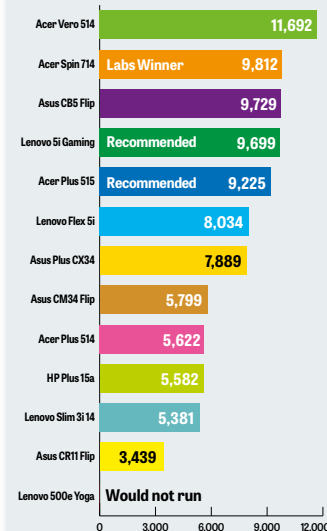


GFXBench Car Chase

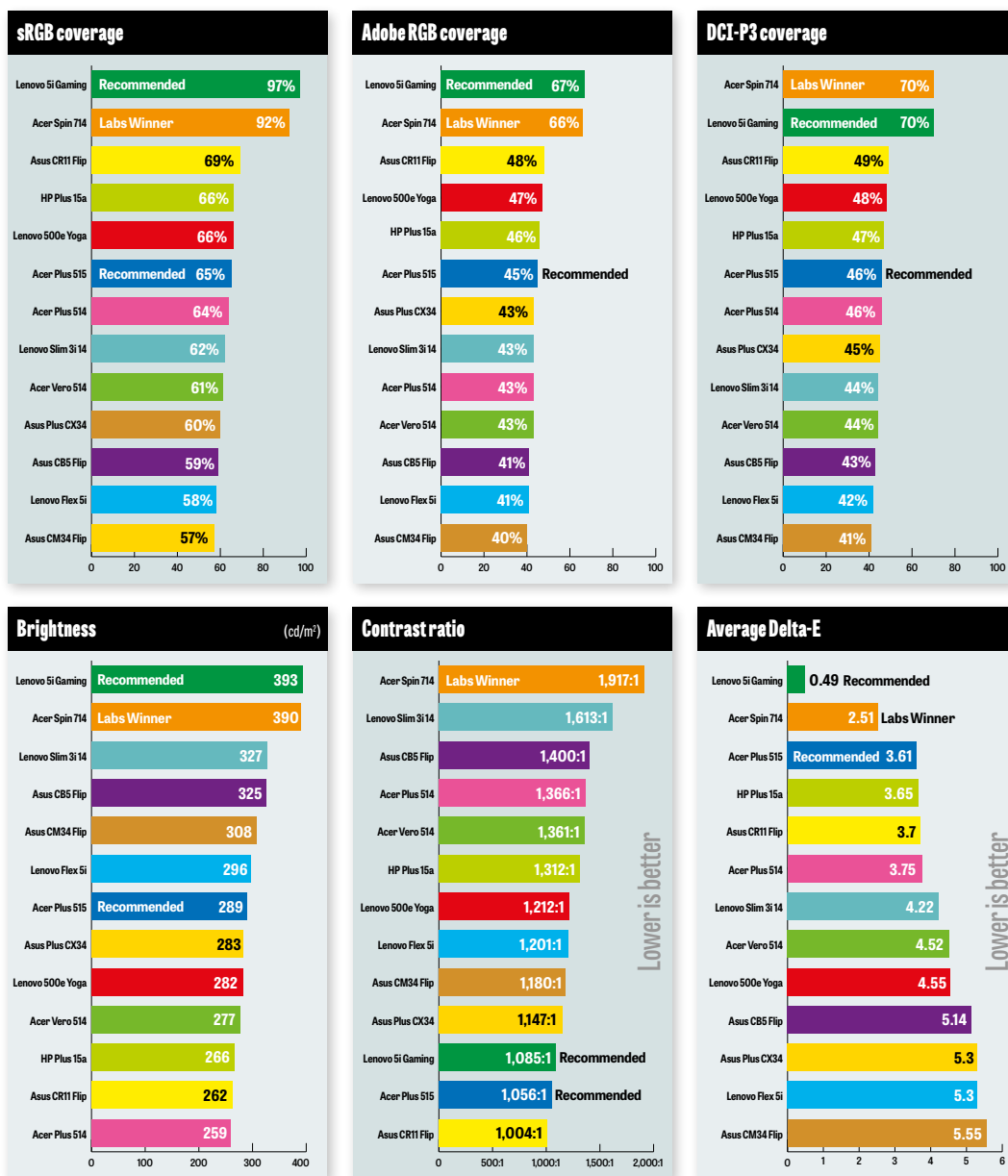
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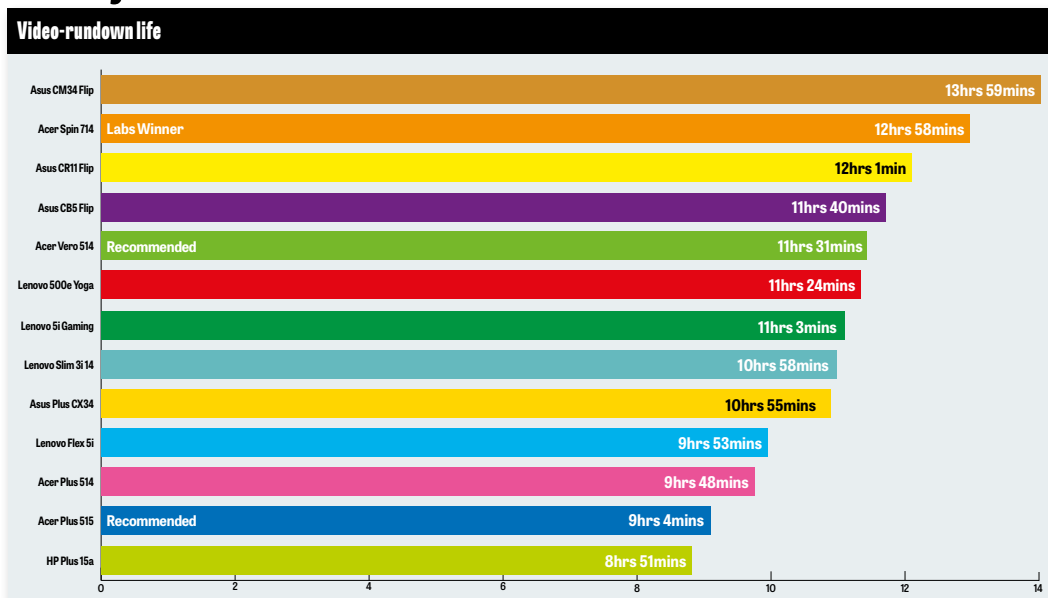
Geekbench 6 Compute



Screen tests



Battery tests



View from the Labs

Desperately seeking pluses

Last year, Google launched its Chromebook Plus initiative, creating a higher tier of Chromebooks. These, Google promised, could do so much more, whether that's handling demanding apps or exploring the exciting new world of AI. It brought Acer, Asus, HP and Lenovo on board, and even threw in some perks and bonus features. And this, Google promised, was just the start! We'd get even more cool AI features as time went on.

Well, six months later, something appears to have gone awry. On the one hand, I'm unsure all the Chromebook Plus models really belong on this higher plane. Some are clearly existing budget or mid-range Chromebooks with the new branding and software slapped on. At least four are based on CPUs that – arguably – aren't up to handling more challenging scenarios and apps.

Despite Google's efforts, manufacturers seem reluctant to bet big on innovative and stylish designs with premium features. Instead, they're sticking to the pile 'em high, sell 'em cheap sales model.

And where are those promised cool features? When all the hype appeared about Chromebook Plus and its integrated AI features, I expected more than a couple of video call enhancements, a bunch of free software and trial services and some screensavers. So far, there's little sign of AI becoming the Chromebook's killer app.

That's a shame, as there's still encouraging evidence that Chromebooks can be great all-round computers. But if Google wants to steal market share from rivals, then it needs to give its users something tangible that will seriously improve their experience of Chrome OS.



Stuart Andrews has reviewed every major Chromebook that's been released and, despite this column, genuinely likes them

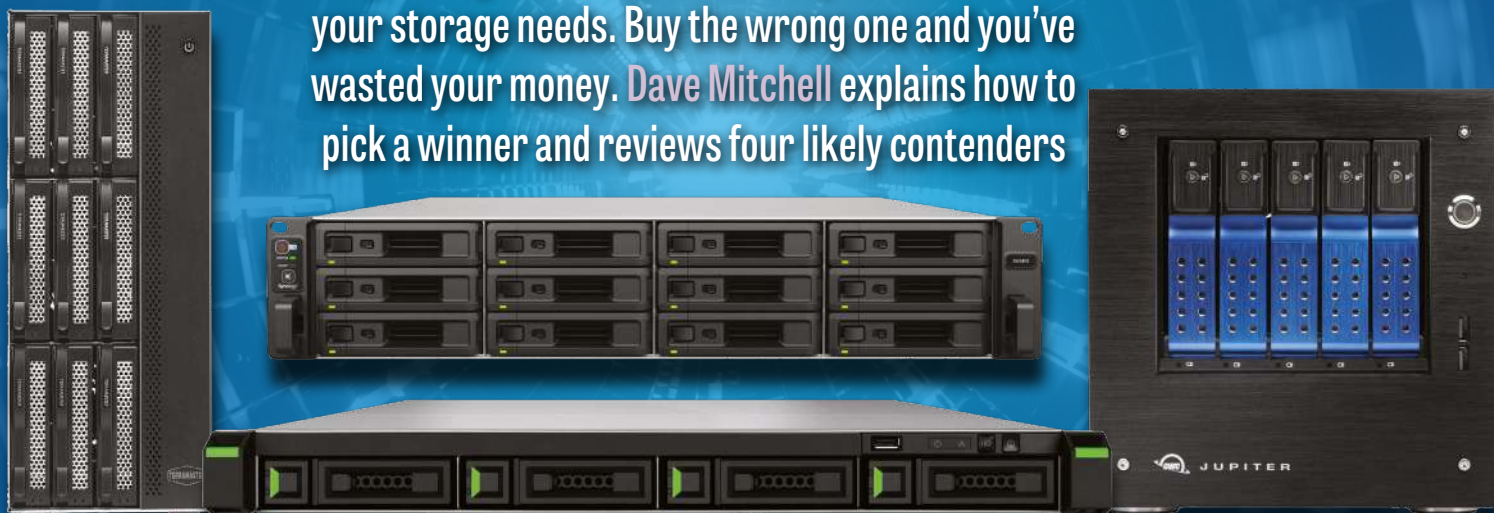
The Network

Practical buying and strategic advice for IT managers and decision makers

Buyer's guide

NAS appliances 2024

Buy the right NAS appliance and you can solve all your storage needs. Buy the wrong one and you've wasted your money. **Dave Mitchell** explains how to pick a winner and reviews four likely contenders



Network attached storage (NAS) appliances are the perfect solution for growing businesses facing a storage crisis. They offer a high-capacity and cost-effective solution that provides teams with fast local access to data and can grow as demand increases.

Cloud storage is a natural contender for these duties but, once you take into account the regular monthly fees, such services can become expensive over the long term – especially if you're using them to store increasingly large amounts of data. It's true that NAS appliances represent a much higher initial spend, but ongoing costs will be comparatively insignificant.

NAS appliances are also more versatile than cloud storage as they provide a ready-made repository for on-site server and workstation backups and won't be impacted by internet and service outages. You don't have to worry about a cloud provider's "shared responsibility model" either, as moving storage

in-house means you have total control over all aspects of data governance.

There's a huge range of NAS appliances on today's market with capacities to match every demand and prices to suit all budgets. This month, we test business-class desktop and rack models from four leaders – OWC, Qsan, Synology and TerraMaster – and put them through their paces in the lab to help you choose the right one.

Are you being served?

Think about what you want your NAS to do over the coming years, as it's

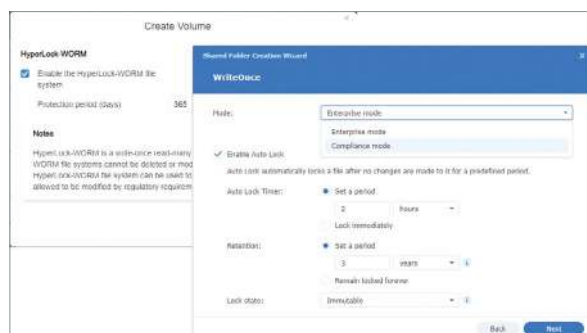
"NAS appliances are more versatile than cloud storage as they provide a ready-made repository for on-site backups"

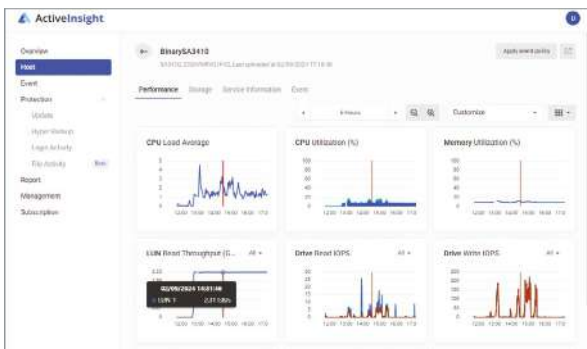
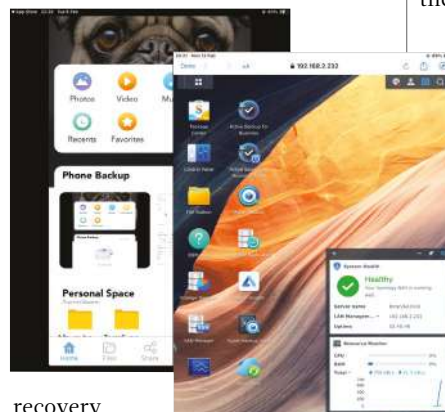
BELOW WORM provides extra data security and ransomware protection

more cost-effective to buy one that has room to grow with you. File serving is a given, but if you plan on using it as a backup vault, a private cloud or to offload storage from servers and workstations, you'll need plenty of spare capacity.

Always go for more drive bays than you think you need as it's much easier to add extra storage devices and expand the RAID array into them. Yes, you can swap out existing drives for larger ones, but each rebuild can take days to complete and a RAID5 array may be vulnerable as another drive failure during this phase could cause complete data loss.

For general storage duties, choose SATA drives as they offer good performance, are affordable and come in a wide range of capacities. You should only use NAS-specific models as these are designed for continuous operations and have built-in protection features such as vibration compensation technology.





Check each vendor's hardware compatibility lists and ensure the drives are certified for your choice of appliance. Compatibility testing and validation is expensive for NAS vendors, and one participant in this guide has a strict support policy for its business NAS appliances that only permits its own brand of drives to be used in them.

Easy as 3-2-1

NAS appliances have a key role to play in a business backup strategy. The most popular plan for reliable data protection is "3-2-1", where you retain three up-to-date copies of your data, back it up to two different types of media and keep one copy off-site.

A NAS appliance is a perfect candidate for the first backup stage as it provides a ready-made repository offering fast on-premises data

need to purchase a third-party backup application to achieve this. Some NAS vendors offer free apps that run on the appliance and can manage workstation, server and virtualisation host backup and can integrate directly with cloud providers such as Amazon S3 and Microsoft Azure.

Need for speed

If your NAS is providing multiple services such as file serving, syncing and backup, ensure it has enough network bandwidth to avoid becoming a bottleneck. Gigabit ports are a standard feature, but many appliances include 2.5GbE multi-gigabit ports.

A network switch that supports these speeds will be required but a big advantage of multi-gigabit links is that they can deliver these higher speeds over legacy Cat5e cabling. If your need

recovery services. For off-site stage, you have a wide range of options as all good appliances have replication services that can copy backup data to a remote appliance or use cloud storage.

You may not

TOP OWC's Jupiter Mini has the TrueNAS Scale OS preinstalled

ABOVE LEFT To test the Qsan appliance, we used four 22TB WD hard disks

LEFT Synology's ActiveInsight provides cloud monitoring

ABOVE Some NAS vendors provide mobile apps to remotely monitor their appliances

"NAS appliances are just as vulnerable to hackers as workstations and servers, so it's important to lock down access"

for speed is greater, choose an appliance that has integral 10-gigabit (10GbE) ports or spare PCI-E slots for additional 10GbE adapter cards.

Another feature that can improve performance is SSD caching, and the four appliances in our guide support this. Bear in mind that only random read and write operations will see any significant improvements, and appliances that use operating systems based on the ZFS file system negate the need for SSDs as their adaptive read cache (ARC) and ZFS intent log (ZIL) features are already very efficient.

Data security

NAS appliances are just as vulnerable to hackers as workstations and servers, so it's important to lock down access. First up is the default administrator account, which should be disabled and replaced with one of your own choosing.

Many vendors have already wised up to this potential loophole as, during appliance installation, they disable the default account and force you to create a new one. Another valuable feature to look for is two-factor authentication (2FA), which requires a second step, such as a mobile code, to be entered before access is allowed.

NAS data needs to be protected from ransomware attacks, and a relatively new feature that can thwart them is WORM (write once, ready many). Previously, WORM was only available on NAS appliances that use a ZFS-based file system but many that employ the Btrfs file system also offer this.

Look for features such as WriteOnce and HyperLock-WORM, which can turn selected NAS shares or volumes into immutable storage. Once data is written to protected shares, it can't be modified or deleted until the retention period you set during creation has expired. Some go further and also stop the entire share and storage pool from being deleted.

NAS appliances have a lot to offer SMBs, with the latest business-class models providing high capacities and a wealth of features.

Intense competition is keeping prices down, making them very affordable, so read on to see which one is the right fit for your business.



OWC Jupiter Mini

OWC brings affordable TrueNAS Scale power to the desktop with a speedy storage appliance

SCORE ★★★★★

PRICE 20TB, £2,475 exc VAT from megamac.com

With a track record stretching back over 35 years, OWC (Other World Computing) has built up an extensive portfolio of storage components and complete business solutions. Stepping in at the entry point of its Jupiter NAS family, the Mini is a desktop storage appliance that's pretested and ready for use.

We reviewed the 20TB model, which came with five labelled 4TB Toshiba MGo8 SATA enterprise HDDs that are loaded by pushing them into the corresponding spring-loaded drive slot. It may be small but the Mini is no lightweight, as it's powered by a quad-core 2.2GHz Intel Xeon D-1518 CPU plus a generous 32GB of DDR4 memory, offers dual gigabit and 10GbE copper ports and has a spare PCI-E expansion slot should you need more.

A standout feature is the preloaded iXsystems TrueNAS Scale operating system (OS). Many will be familiar with the FreeBSD Core version, but the Debian Linux-based Scale offers more storage features along with integral virtual machine (VM) hosting.

You won't be wholly relying on the TrueNAS community for help, either, as OWC provides full customer support. This covers deployment and troubleshooting



PC PRO
RECOMMENDED

and includes a three-year hardware warranty, extendable to five years.

No storage configuration is required since the OS runs on a 16GB SSD plug-in module on the appliance's Supermicro motherboard and the five supplied drives come preconfigured as a Z1 array – the equivalent of RAID5. On first contact, the appliance presents the standard TrueNAS Scale web interface, with a customisable dashboard showing essential information on system utilisation and storage.

For share provisioning, you create a dataset or select an existing one, name the share, choose a purpose from the predefined list and secure it using the appliance's access control list (ACL). IP SAN setup is equally simple: you can use Zvols or datasets for block or file devices, create portals and assign CHAP authentication if required.

Visit the app discovery page and you'll find over 100 apps available,

ABOVE The Jupiter Mini is OWC's entry-level NAS, but it has plenty of features

"OWC provides full support that covers deployment and troubleshooting and includes a three-year hardware warranty"

BELOW TrueNAS Scale delivers an informative web console

but workstation and server backup isn't on the list so you'll need to source separate third-party applications for securing these systems to the NAS. On the plus side, you can create scheduled tasks to secure NAS data to a wide range of cloud storage providers and if the appliance is presenting VMFS

datastores to VMware hosts, you can use its VMware Snapshot feature to protect them.

The Mini returned good results in our 10GbE performance tests. With a share mapped to a Dell PowerEdge R760xs Window server, Iometer reported sequential read and write rates of 8.3Gbits/sec and 9.2Gbits/sec and random speeds of 8.3Gbits/sec and 8.5Gbits/sec.

The last two numbers show the efficiency of the TrueNAS ZFS read and write caching, and we noted during our tests that this didn't consume more than 1GB of system memory. IP SAN speeds were a mixed bag, though, with a 1TB iSCSI target returning top sequential and random read rates both of 9.2Gbits/sec but noticeably lower write speeds of around 5.7Gbits/sec.

The ZFS-based file system delivers top-notch data protection with copy-on-write (COW) delivering near unlimited

NAS and iSCSI LUN snapshots. End-to-end checksums handle data corruption, and snapshots can be replicated to remote appliances.

NAS share contents may be protected from tampering or deletion by activating WORM (write once read many). Space-saving features are plentiful as TrueNAS Scale applies inline compression and you can enable deduplication on datasets.

With the 20TB model costing £2,475, the Jupiter Mini is comparatively good value. Its TrueNAS Scale OS delivers solid data integrity features plus speedy 10GbE performance, and it will appeal to SMBs seeking a preconfigured storage solution with a warranty that covers the appliance and hard disks.

SPECIFICATIONS

Desktop chassis • 2.2GHz Intel Xeon D-1518 • 32GB DDR4 RAM (max 64GB) • TrueNAS Scale OS • 5 x 4TB Toshiba MGo8 hot-swap hard disks in RAID Z1 array • 2 x 1GbE, 2 x 10GbE RJ-45 ports • gigabit IPMI • PCI-E x16 slot • 4 x USB-A • VGA • 221 x 324 x 235mm (WDH) • internal PSU • 3yr OS support and hardware warranty



Qsan XCubeNAS XN5104R

An affordable, low-profile storage solution with huge expansion potential and good 2.5GbE performance

SCORE ★★★★★

PRICE **Diskless, £1,278 exc VAT**
from [lambda-tek.com](https://www.lambda-tek.com)

Representing the entry point of Qsan's new NAS appliance family, the XCubeNAS XN5104R offers SMBs a small footprint storage solution with plenty of room to grow. This competitively priced 1U rack NAS presents four hot-swap LFF/SFF SATA drive bays at the front, secretes a pair of NVMe SSD slots inside and teams them up with four 2.5GbE multi-gigabit ports.

A quad-core 2.3GHz Intel Xeon D-1714 CPU sits in the driving seat and is partnered by 8GB of DDR4 which can be expanded hugely to 256GB. There's room for more network ports, as the spare PCI-E Gen4 slot accepts Qsan's dual-port 10GbE and 25GbE cards.

A compelling feature of Qsan's NAS appliances is their enormous expansion potential, and the XN5104R is no exception. Fit Qsan's SAS3 PCI-E card and you can daisy-chain a mix of external disk shelves for a total of 414 drives and a maximum raw capacity of 9PB.

For deployment, we loaded four 22TB Western Digital Red Pro NAS drives and used the XFinder app to



discover the appliance and install the latest QSM software. From the custom setup option, we created a big RAID5 storage pool and, if you install NVMe SSDs, you can assign one or both to a pool as a hybrid cache, which accelerates both read and write operations.

QSM offers plenty of storage management and data integrity features. The ZFS-based OS includes copy-on-write snapshots for NAS shares and iSCSI LUNs, in-line data deduplication, intelligent real-time data tiering and facilities for applying one of three WORM (write once read many) policies to NAS share data. You can use a policy to guarantee nothing already in a share can be modified, set it so that only new files copied to the share have the retention date applied, or stop anything from ever being modified or deleted by applying a WORM forever policy.

The QSM web console is easy to navigate but apps are in short supply, with Qsan only including ones for file and media management, hardware monitoring, antivirus, backup and cloud syncing. It used to offer VPN, SQL database, web services and hypervisor manager apps, but these were dropped from QSM a while ago.

The apps Qsan does provide are easy to use, however. The Backup app manages snapshot scheduling

ABOVE It may have a small footprint, but the XCubeNAS has huge potential



"Fit Qsan's SAS3 PCI-E card and you can daisy-chain a mix of external disk shelves for a total of 414 drives and a maximum capacity of 9PB"

LEFT The XN5104R can be remotely managed using Qsan's XInsight webserver

and can secure appliance data to any Rsync-compliant remote appliance, as well as Amazon S3, Alibaba OSS and HiCloud S3 cloud accounts.

It can replicate folders between XCubeNAS appliances using the Xmirror service, while the Cloud Sync app handles one-way and two-way sync jobs with Dropbox, OneDrive and Google Drive.

Qsan fans will like the free XInsight app, which offers central management for all their AFA, NAS and SAN appliances. Run as a web service on any Windows host, its web console provides an overview of all activity, storage usage and alert notifications plus quick access to each appliance's management console.

Performance over 2.5GbE is good.

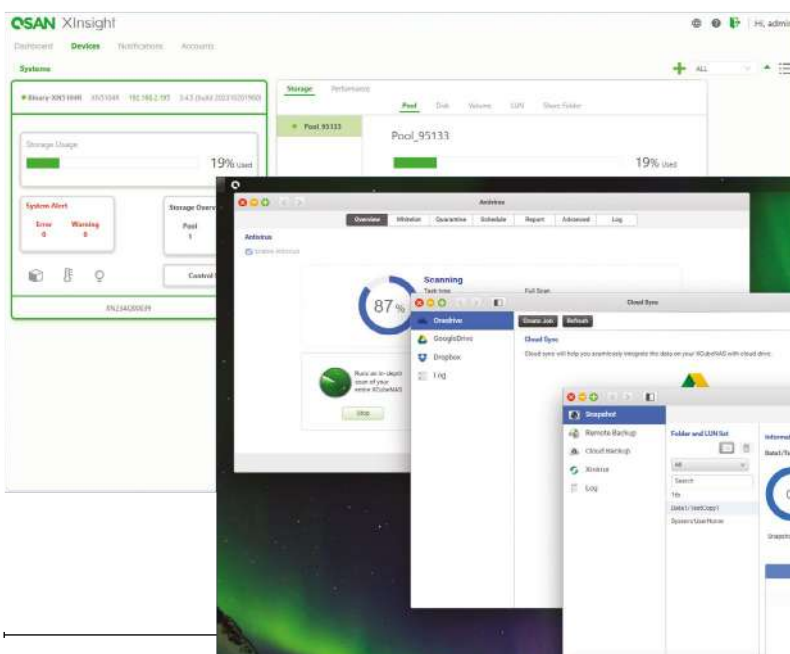
A share mapped to a Dell PowerEdge R760xx Windows Server 2022 host returned 2.3Gbits/sec and 2.2Gbits/sec for both Iometer sequential and random read and write tests, and the XN5104R delivered identical results in our 2.5GbE IP SAN tests. For the latter, we increased the pressure with a dual 2.5GbE MPIO link to our 1TB iSCSI target and recorded sequential reads and writes of 4.6Gbits/sec and 4.2Gbits/sec, while random operations held firm at 4.6Gbits/sec and 4Gbits/sec.

SMBs looking for a good-value rack NAS appliance with an enormous potential for capacity expansion will find a lot to like about Qsan's XCubeNAS XN5104R.

It's light on apps but big on 2.5GbE performance, and Qsan's QSM software delivers great data integrity and storage management features.

SPECIFICATIONS

1U rack chassis • 2.3GHz Intel Xeon D-1714 processor • 8GB DDR4 RAM (max 256GB) • 4 x LFF/SFF SATA hot-swap bays • 2 x M.2 NVMe sockets • supports RAID0, 1, 5, 6, Z3, 10, 50, 60 • 4 x 2.5GbE ports • PCI-E Gen4 slot • 2 x 450W hot-plug PSUs • 3yr hardware warranty





Synology SA3410

A speedy hybrid storage solution with big expansion potential and valuable data integrity features

SCORE ★★★★★

PRICE Diskless, £5,476 exc VAT from broadbandbuyer.com

Synology's "SA" family of rack NAS appliances are aimed at the mid-range and enterprise storage markets and deliver a wealth of features, top performance and a high scalability. The SA3410 on review is the entry point of the range and, along with support for SAS3 and SATA devices, it sports an 8-core 2.1GHz Xeon D-1541 CPU, 16GB of DDR4 memory (upgradable to 128GB) and a feast of gigabit and 10GbE network ports.

Businesses looking to upgrade their elderly SA3400 appliances won't be impressed, though. Apart from a single digit name change, the only difference between them is the SA3410 adds an extra gigabit port to isolate management traffic.

That said, the SA3410 has a lot to offer businesses that want plenty of room for future growth. The external port on its Synology SAS12G adapter card supports up to seven 12-bay RX1222sas disk shelves for a total of 96 drives, and the two spare PCI-E slots accept Synology's dual-port 10GbE and 25GbE network cards.

Be careful with your choice of storage devices, as the SA3410 only supports Synology's HAT HDDs and SAT SSDs. For testing, we loaded eight 480GB SAT5200 SATA SSDs, which were accepted without any

issues, but use uncertified drives and they'll flag up errors in the web console and Synology will decline to provide support.

Synology's discovery web portal simplifies deployment, as it quickly found the appliance on our lab network and downloaded the latest DSM 7.2 software. For performance testing, we used the DSM Storage Manager app to create a single RAID5 array from all eight SSDs.

The Xeon D-1541 CPU may be over eight years old but it still has what it takes for performance. With a share mapped over 10GbE to a Dell PowerEdge R760xs Windows Server 2022 host, Iometer reported top sequential read and write rates both of 9.3Gbits/sec. The SSD array made its presence felt when we swapped to random read and write operations, with the share returning 9.2Gbits/sec and 8.4Gbits/sec respectively.

IP SAN speeds are on the money, too, with a 500GB iSCSI target presented to the server over 10GbE delivering the same sequential and random speeds as our NAS tests. Upping the pressure with a dual 10GbE MPIO link to the target saw sequential read and write rates of 18.5Gbits/sec and 17.7Gbits/sec, while random operations settled at 18.5Gbits/sec and 15.1Gbits/sec.

ABOVE The SA3410 provides a feast of gigabit and 10GbE network ports



"Synology's Active Backup suite comprises three apps for securing servers, workstations and virtualised environments"

Synology's DSM 7.2 has a sharp focus on data security and ransomware protection: along with full volume encryption, it provides WORM (write once, read many) policies for NAS folders on Btrfs volumes. Called WriteOnce, you select it during shared folder creation and choose Enterprise or Compliance policies that apply customisable file lock periods, enforce retention periods in days, years or forever, set files as immutable and stop storage pools, volumes and shared folders from being deleted.

The SA3410 is perfect for backup duties, with DSM offering a wealth of free apps. The star player is

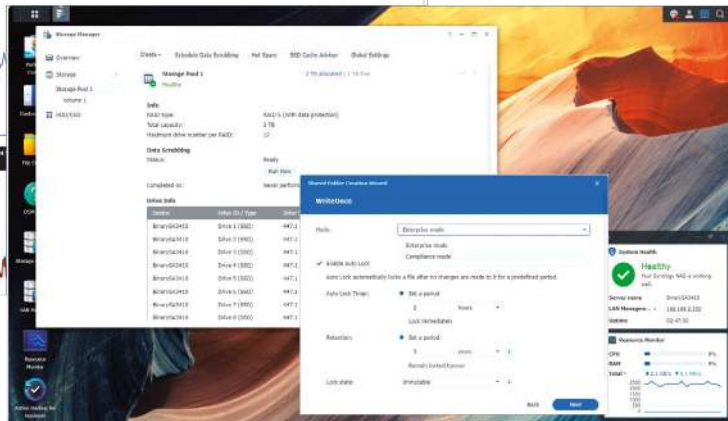
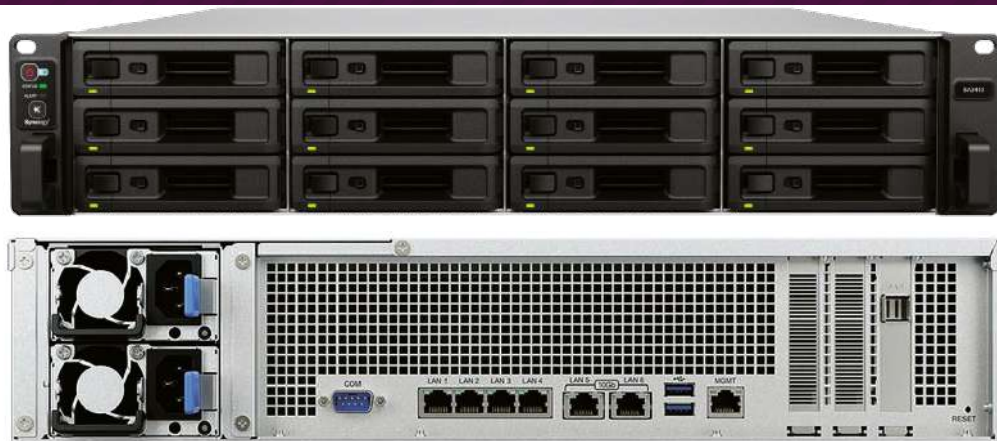
Synology's Active Backup suite which comprises three apps for securing servers, workstations and virtualised environments, along with Google Workspace and Microsoft 365.

The Snapshot Replication app manages NAS and IP SAN snapshots and offers fast rollback services along with NAS share file and folder recovery using the File Station app. Local, remote, Rsync, cloud and iSCSI LUN backups are looked after by the Hyper Backup app, while the Drive Server app provides synchronisation services for collaboration and file sharing.

Synology's SA3410 delivers a powerful storage package that returned impressive 10GbE performance results in our lab tests. Add in its SAS3/SATA device support, high expansion potential and feature-packed DSM software and you have an enterprise-class storage solution at an SMB price.

SPECIFICATIONS

2U rack chassis • 2.1GHz Intel Xeon D-1541 processor • 16GB DDR4 RAM (max 128GB) • 12 x LFF/SFF SAS/SATA hot-swap bays • Synology SAS12G PCI-E RAID card • supports RAID F1, 0, 1, 10, 5, 6 • 4 x 1GbE, 2 x 10GbBaseT ports • gigabit management port • 2 x PCI-E Gen3 • 2 x USB-A 3.2 Gen 2 • 2 x 500W hot-plug PSUs • 5yr hardware warranty



BELOW Synology's ActiveInsight provides remote monitoring

TerraMaster T9-450

A good-value desktop NAS with plenty of capacity, a fine selection of ports and good data protection services

SCORE ★★★★★

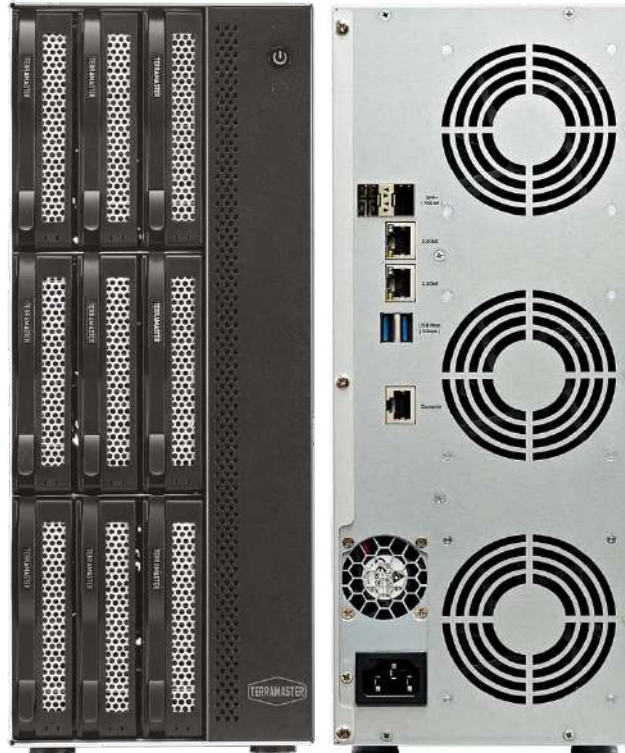
PRICE Diskless, £916 exc VAT
from [amazon.co.uk](https://www.amazon.co.uk)

TerraMaster's T9-450 will appeal to SMBs that want an affordable NAS appliance that puts a pile of storage on their desktop. Designed to stand on its side or base, it delivers nine hot-swap SATA drive bays and teams them up with dual 2.5GbE multi-gigabit and 10GbE SFP+ ports.

Enclosed in a sturdy steel chassis, the appliance is driven by a 2.4GHz quad-core Intel Atom C3558R CPU partnered by 8GB of DDR4 memory, expandable to 32GB using the two SODIMM slots. Upgrades are easy: you only need to remove the side cover to access the motherboard, and you'll also find two M.2 NVMe SSD slots, which can be used as a standard storage pool or a performance-boosting cache.

For testing, we fitted four 14TB WD Red Pro hard disks in the metal hot-swap carriers and slotted in two 480GB Kingston NVMe SSDs. These were all accepted without any complaints, and it's also worth mentioning that the appliance's three rear 8cms diameter fans are whisper-quiet.

Installation is handled by a browser-based wizard, which downloaded and applied the latest TOS 5 operating system. We opted for a RAID5 array, but if you have



disks of different sizes you can choose the RAID option, which will use them all without incurring any capacity overheads.

To test maximum performance, we hooked the appliance up over 10GbE to a Dell PowerEdge R760xx Gen4 Xeon Scalable server running Windows Server 2022. NAS speeds were reasonable, with a mapped share returning Iometer sequential read and write rates of 9.2Gbits/sec and 5.9Gbits/sec, while copies of a 25GB test file between the appliance and server averaged 3.1Gbits/sec and 4.6Gbits/sec.

IP SAN performance was in the same ballpark, with a 1TB iSCSI target recording sequential read and write rates of 9.2Gbits/sec and 6.7Gbits/sec. Swapping to a dual 10GbE MPIO link to the target saw

ABOVE The sturdy steel chassis is designed to stand on its side or its base

"Backup features are plentiful, with the Backup app providing a central location for quick access to all associated modules"

BELOW The TOS 5 software provides plenty of good data protection services

speeds ramp up to 16.3Gbits/sec and 8Gbits/sec respectively.

An NVMe SSD cache may benefit workloads generating a lot of random write operations. Using the TOS Hyper Cache feature, we configured our SSDs as a RAID1 read/write cache and saw random writes for our NAS share and iSCSI target improve by 135% and 280% respectively.

TOS 5 delivers in the data protection stakes with the HyperLock-WORM feature allowing volumes to be assigned custom retention periods of up to 70 years to stop stored data being modified or deleted. TOS won't allow you to decrease the set period and it applies this to standard Btrfs volumes – Qnap and Qsan can only do WORM on their ZFS-based file systems.

Backup features are plentiful, with the main Backup app providing a central location for quick access to all associated modules. Btrfs file system, NAS share and iSCSI LUN snapshots

can be run at regular intervals, TFM (TerraMaster folder mirror) handles local or remote copies of shared folders, and CloudSync supports 12 storage providers, including Amazon S3, OneDrive, Box and Dropbox.

The Centralized Backup app is now fully functional as we could secure virtual machines on our Hyper-V and VMware ESXi hosts and restore them back

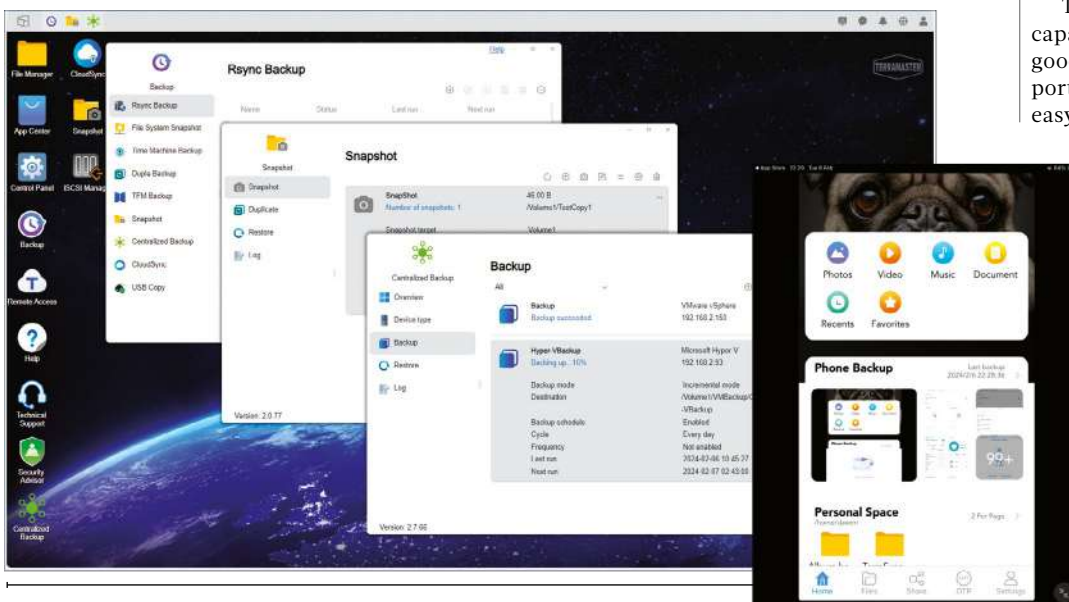
to their original location or as new VMs. Private cloud services come courtesy of the TerraSync Server app, and the latest TNAS PC 5.1 Windows app allows you to connect desktops to the appliance and create jobs that sync the contents of local and remote folders.

The T9-450 delivers a high storage capacity for the price and includes a good helping of 2.5GbE and 10GbE ports. Smart chassis design makes it easy to upgrade, performance over

10GbE is respectable and TerraMaster's TOS 5 OS delivers lots of data protection and VM backup features.

SPECIFICATIONS

Desktop chassis • 2.4GHz Intel Atom C3558R processor • 8GB DDR4 RAM (max 32GB) • 9 x LFF/SFF SATA hot-swap drive bays • supports RAID0, 1, 5, 6, 10, TRAI • 2 x 2.5GbE, 2 x 10GbE SFP+ ports • 2 x M.2 2280 NVMe SSD sockets • 2 x USB-A 3.2 Gen1 • 135 x 295 x 334mm (WDH) • 250W internal PSU • 3yr limited warranty





TP-Link VIGI NVR1004-4P

A low-cost surveillance and recording solution with good analytics features that work best with TP-Link's cameras

SCORE ★★★★★

PRICE £93 exc VAT
from ballicom.co.uk

TP-Link may be best known for its affordable business networking products, but it also has a strong presence in the video surveillance market. Its VIGI family offers a range of network video recorders (NVRs) and cameras, and in this review we look at its NVR1004-4P four-channel NVR and test it with TP-Link's latest C540V outdoor PTZ IP camera.

Costing under £100, the NVR looks great value but you'll need to add the extra cost of a SATA hard disk to store video recordings. At the rear are four network camera ports, each delivering PoE+ services, and it has a total power budget of 53W.

HDMI and VGA ports support local monitors, two old-school phono jacks are provided for audio in and out and a separate Fast Ethernet port facilitates NVR web management. Setup is easy; after fitting a 4TB Western Digital Red Pro hard disk in the NVR, we connected an HD monitor and followed the onscreen wizard.

To secure access, you choose an admin password and provide a recovery email address. You can also set a global username and password as well as a recovery email that are applied to VIGI cameras when they first come online.

The wizard finishes by displaying QR codes for TP-Link's VIGI mobile apps. To use them, you create a TP-Link ID account and bind the NVR to it from its web console. We also loaded TP-Link's Security Manager app on a Windows host and linked it to our ID account for remote NVR access, although this doesn't provide event management.

To add the C540V camera, we connected it to a PoE port and waited ten seconds while the NVR discovered it. All security settings and firmware updates were applied for us, and the NVR assigned a base set of video parameters that included enabling the latest H.265+ codec.

This IP66-rated camera delivers great image quality. Along with good contrast and colour balance, it has a sharp focus, handles bright sunlight well and its motorised pan and tilt functions cover a lot of ground. The IR LED provides good night illumination up to around 20 metres, its white LEDs are

blindingly bright, and the powerful integral speaker will scare the living daylight out of intruders.

The NVR1004-4P can't match Synology's DVA appliances, which provide slick people counting, face recognition and crowd

control features, but it does offer a good range of detection and recording features. For basic motion detection, you draw multiple polygonal shapes in the camera view where you want it applied, set object height and width filters, tweak the sensitivity and enable human and vehicle detection.

Smart events go further, and allow you to draw lines in the camera view to denote digital fences and choose one-way or two-way directions. Custom detection zones can be monitored for objects being removed or those that linger in them for a specific period, while entry and exit regions are used to keep an eye on specific areas such as

building entrances.

Along with event recording, trigger actions can include pop-up warnings, sounding NVR and camera audio alarms and activating a camera's security lights.

Recordings can be viewed from the NVR's local monitor or web console, the Security Manager and mobile app, with options to choose camera channels and scroll through their timelines to points of interest.

The NVR1004-4P supports ONVIF-compliant IP cameras and it discovered our D-Link models as soon as we connected them to the PoE ports. We customised the live view to show all camera feeds, but features are more limited as we could only apply basic motion detection events to them.

You'll need to use TP-Link's VIGI cameras to get the best from it, but the NVR1004-4P is a good choice for small businesses seeking affordable in-house video surveillance. It offers plenty of video analytics features, the C540V camera scores highly for image quality, and the components are offered at very competitive prices. **DAVE MITCHELL**

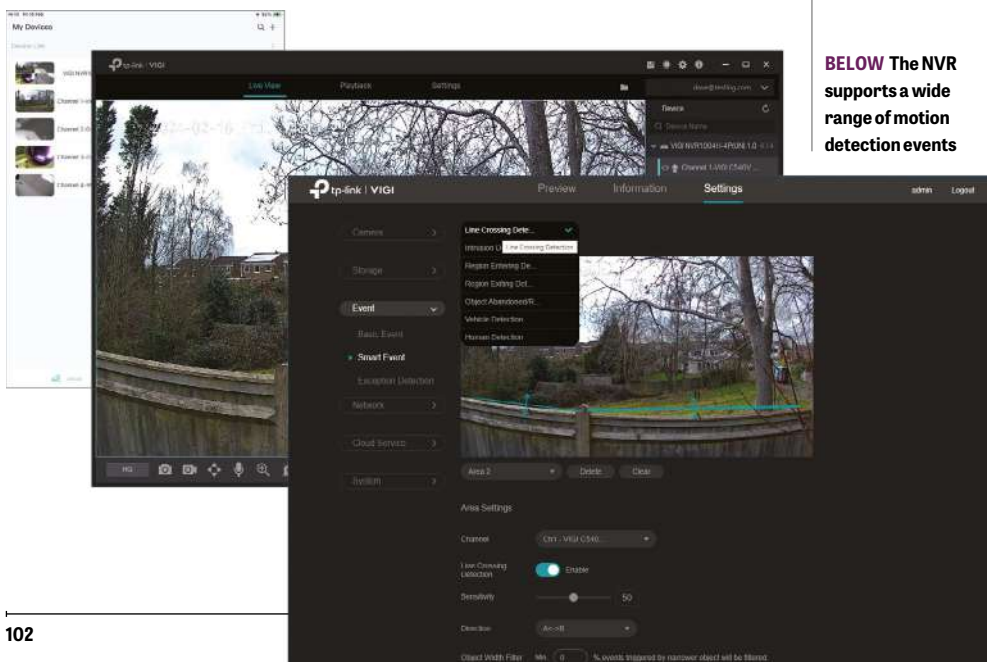
SPECIFICATIONS

Desktop fanless chassis • 4 x RJ-45 network camera ports with PoE+ • 53W power budget • 10/100 management port • SATA interface (drive not included) • HDMI • VGA • audio in/out • 2 x USB-A 2 • 246 x 148 x 45mm (WDH) • external power supply • web browser management, VIGI mobile app, VIGI Security Manager • 3yr limited warranty

ABOVE It's great value, but you'll need to add a SATA hard disk to store recordings

"The NVR1004-4P can't match Synology's DVA appliances, but it does offer a good range of detection and recording features"

BELOW The NVR supports a wide range of motion detection events



Zyxel XMG1915-10EP

A pocket-sized switch that delivers multi-gigabit ports and high-power PoE++ services at a tempting price

SCORE ★★★★★

PRICE £257 exc VAT
from broadbandbuyer.com

Zyxel's XMG1915 family of switches is aimed at small businesses that want plenty of multi-gigabit ports in a space-saving design and at a competitive price. The range comprises three models, and we reviewed the XMG1915-10EP, which provides high-power PoE++ services.

Measuring only 250 x 104 x 27mm (WDH), this desktop switch packs in eight 2.5GbE multi-gigabit ports all capable of delivering up to 60W. It partners them with a pair of 10GbE SFP+ fibre ports for high-speed uplinks. It has a good power budget of 130W, which is facilitated by a chunky 150W external power brick that's over half the size of the switch.

The switch uses its chassis as a heatsink and its fan-less design means it's completely silent. Management options are good: you can run it in standalone mode or hook it up with Zyxel's Nebula Control Center (NCC) service for full cloud access.

The switch packs plenty of LEDs into its front panel, with lights showing system and cloud connection status, while a three-colour PoE LED warns if you're getting close to the power budget. Each port is also assigned an LED that shows whether its connection speed is 100Mbps/sec, gigabit or 2.5GbE.



The switch is easy to deploy in standalone mode, with its local web console presenting four wizards for setting a default admin password and SNMP community names, and configuring security features, VLANs and quality of service (QoS). Not that it will concern the target audience, but the XMG1915-10MP is a pure Layer 2 switch and doesn't offer the "Lite-L3" static routing features found in Zyxel's larger PoE switches.

Standard L2 features are plentiful and include port and protocol-based VLANs plus static and LACP link aggregation groups. VoIP networks are on its radar as the switch identifies traffic from IP phones using a customisable organisationally unique identifier (OUI) list and automatically prioritises it by dynamically creating voice VLANs.

The web console's dashboard shows details on system utilisation, port speeds, whether they're supplying power and overall power consumption for all connected powered devices (PDs). One of three power priorities can be assigned to each port so if the power draw gets close to the maximum available, those with the lowest priority will be switched off first.

Unless you're planning on deploying power-hungry PoE IP cameras with integral PTZ functions, it's unlikely you'll get close to the

ABOVE The diminutive XMG1915-10EP packs in eight 2.5GbE multi-gigabit ports



"Management options are good: you can run it in standalone mode or hook it up with Zyxel's Nebula Control Center for full cloud access"

maximum power budget. We tested this by connecting two Zyxel Wi-Fi 6E access points (APs) and the new WBE660S Wi-Fi 7 model plus Netgear's tri-band WAX630E AP; we saw from the web console that the total draw didn't go above 43W, leaving us with 87W still to play with.

Cloud deployment is swift. We used the Nebula iOS app on an iPad to scan the QR code label on the switch's base. Two minutes later the switch popped up in our cloud portal and received all our site settings, including a new admin password.

The widget-based NCC dashboard can be easily customised and we added widgets to show the online status of our switch and total power usage. Selecting the switch took us to its monitoring page, with colour-coded views of all ports and 24-hour traffic and power graphs, which can

be extended to seven days with an optional NCC Plus licence and to one year with the Pro version.

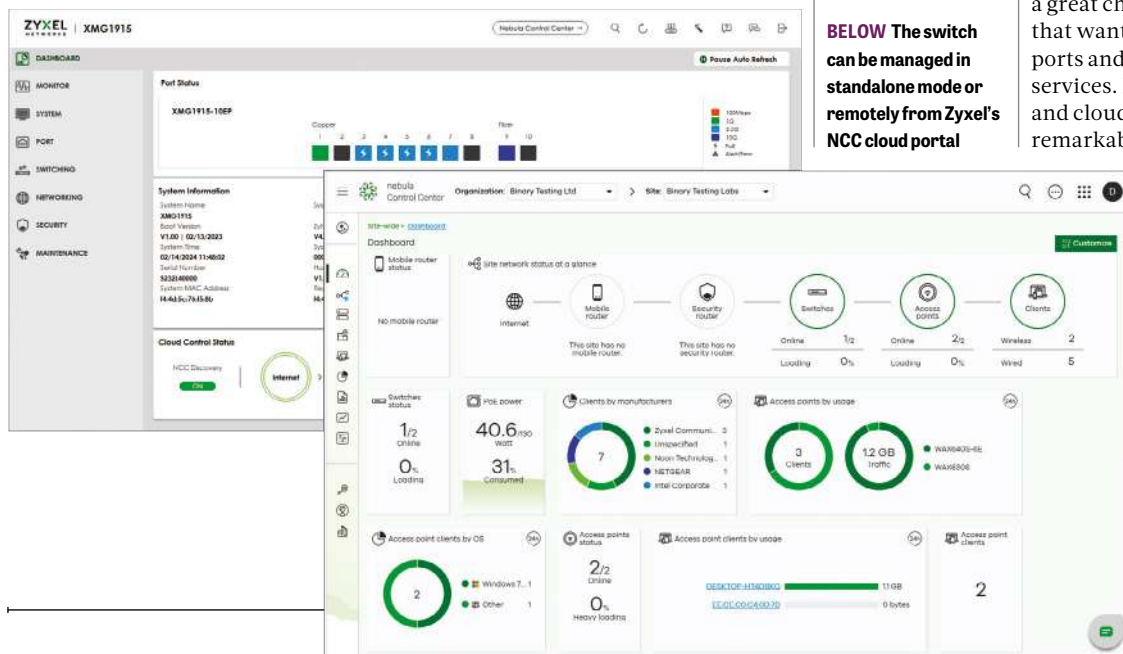
For general switch operations, Nebula provides remote access

to all the same features as standalone mode. Up to five global PoE schedules can be assigned to specific ports that determine when attached PDs are active and you can disable and enable PoE services on each one as well – very handy for remotely rebooting a PD that isn't responding.

The compact XMG1915-10EP is a great choice for small businesses that want plenty of multi-gigabit ports and high-power PoE++ services. It supports standalone and cloud management and the remarkably low price includes

an impressive set of features. **DAVE MITCHELL**

BELOW The switch can be managed in standalone mode or remotely from Zyxel's NCC cloud portal



SPECIFICATIONS

Desktop fanless chassis • 8 x 2.5GbE/60W PoE++ ports • 2 x 10GbE SFP+ ports • 130W power budget • 32MB flash memory • 256MB RAM • 80Gbits/sec backplane capacity • 1.5MB packet buffer • 16K MAC addresses • 150W external PSU • 250 x 104 x 27mm (WDH) • web browser and Nebula management • limited lifetime warranty



Declutter your network

Is your office filled with dusty old servers and trip-hazard cables?
Steve Cassidy explores ways to clean up your network –
and make it faster and more secure in the process

If your network generates equal amounts of data and embarrassment, don't worry – you're not alone. I've visited plenty of blue-chip company machine rooms, and if they're not running at 70°C with every fan at maximum howl then they're frequently a heaving, unsanitary mantrap of patch leads and power cables, primed to spring free from no stronger vibe than a passing tea-trolley. Almost every business can benefit from a network decluttering; not only will this reduce the number of physical points of failure, it can minimise administrative loopholes, vulnerabilities and weird unintended behaviours by bringing everything under a few properly managed and closely monitored roofs.

Subnets and segments

There's one big reason why most networks need decluttering: the fact is that networks tend to be very old, relative to many of the pieces of technology attached to them. I know businesspeople who won't allow any TV more than two years old into their office, where they sit working on a

LAN originally designed and set up more than two decades ago.

Such longevity isn't necessarily shameful. Indeed, you might argue that it reflects good design, and I'm inclined to agree. However, the credit doesn't necessarily go to your network. The really impressive achievements are thanks to pioneers such as Vint Cerf, who designed the protocols, packet structures and so forth that make entire platforms impressively extensible, robust and tolerant of things not being configured precisely as they should.

The downside is that a lot of older networks, whether by original design or through gradual accumulation of cruft, nowadays have only a passing contact with the proper standards. This might well include yours –



ABOVE Dust never sleeps: how old is the kit in your network?

although the fact may only become apparent when some seemingly uncontroversial change or expansion turn out to be mysteriously impossible or unreliable.

One common cause of this problem is when a network is still stuck on whatever IP configuration the implementer deemed suitable at the time. Nowadays we take things such as subnet masks and private address ranges for granted, but back when

we were still figuring out how best to implement company-wide internet access, lots of early engineers took the approach of offering a proxy server with a public address in a DMZ VLAN, so users could reach the internet without incurring expensive NAT per-packet calculations. No doubt

whoever set up your first internet gateway is now long gone, but even if the whole proxy server model is no longer in use, vestiges of it might be. And I doubt many CTOs would feel they could confidently point to a clear and well understood upgrade path.

Another potential issue is the physical infrastructure. Before Cat5e and network switches, Ethernet started out with hubs – dumb devices with no ability to manipulate the traffic flowing through them, which just re-broadcast every packet to everyone, without caring about subnets or other limitations. The smarter bits of a multi-subnet layout, if you had them at all, were taken care of by individual special-purpose devices, such as bridges, repeaters, firewalls and so on. Each of these would have its own quirks and limitations, which could lead to some quite broad restrictions on what your network could do and how it could grow; to this day, some people think there's a limit of 256 devices on a company network. (Some were even lower than that – fancy running your business on a maximum of 16 machines?)

If any of these archaic devices are still lurking in your setup – or if you're still chained to a configuration that was designed around their shortcomings – then it's time you cleaned house. Modern network switches enable vastly more sophisticated and manageable topologies, to the point of treating each connected wired device as its own subnet, should you be that crazy. A good one will actively help you migrate from older hardware to a newer, more software-centric design for your network.

■ This one goes up to 11

While I'm singing the praises of switches, it must be admitted that advanced models are like catnip for paranoid network administrators, and this isn't necessarily a good thing. It's true that routing traffic through multiple VLANs, and configuring a tight link between network access and logging in to the overall technology suite, makes it very straightforward to manage traffic, and extremely difficult for a hacker to find their way in through classic trial-and-error probing.

If only that were the end of the matter. The trouble is that turning all that clever stuff on seriously diminishes the flexibility of the network. Many manufacturers greatly over-specify what goes into their high-end products, leading to switches where you have to be cleared by the US Department of Defense as a safe person before you

can download firmware updates or deploy certain configurations.

Mid-range switches, meanwhile, can suffer catastrophic slowdowns when fully lit up with all their smartest features activated. The smaller businesses that use them may find that they're continually calling back the guy who set it all up to explain why this choice here makes all the difference to that bunch of users over there.

Leaving the hardcore options turned off, at least to begin with, makes debugging otherwise imperfect networks a thousand times easier. The "clutter" here largely comprises worthwhile-sounding protective measures against certain hacking methods; it's far better to implement these measures as part of a complete orchestration-driven view of your IT estate.

■ Flicking switches

There was a time when I could easily recommend that you replace your ageing switches with the latest fanless models. However, in recent years the rise of VoIP has seen the switch business somewhat reinvented; you're nowadays encouraged to upgrade from your nasty old slow, unmanaged switch to an equally nasty new, fan-engorged traffic controller device, with integrated telephony and PoE support. It's hard to say that counts as decluttering.

If you're looking to replace a simple switch that's reaching the limit of its lifetime, I would still recommend fanless models. The chips that drive these things are now easily powerful enough to do their job without active cooling, and as well as being energy-efficient themselves, such devices help the spread of initiatives such as Green Ethernet. In the meantime, while the rest of the market goes galloping off in pursuit of exotic management and monitoring technologies, you can make your life easier by avoiding needless complication.

You should also be thinking about logical switches. I realise that this suggestion may provoke wrinkled snouts, as "logical switch" is not a real industry-standard phrase. To explain

what I mean, let me first note that switches used to be pretty close to "one-size-fits-all", the classic example being the 12-port 3com desktop switch that inhabited every other office. These days, much higher-density devices offer up to 48

gigabit Ethernet ports – and there's also a burgeoning variety of 10GbE-gig capable switches and add-on cards for desktops and servers. Don't get too excited about those: 10GbE of actual throughput is an

elusive goal, and the first step towards achieving it is to declutter and tune your 1GbE LAN. In one sense, therefore, a logical switch is the one that makes sense for your business.

My main meaning of "logical switches", however, is that whole

"10GbE of throughput is an elusive goal, and the first step towards achieving it is to declutter and tune your 1GbE LAN"



ABOVE An inventory of all your network switches can reap huge dividends

class of entities that live inside the multi-layered, multi-dimensional world of cloud computing. This is a world where your servers are in actuality just a set of files in a storage array somewhere in the world, operated by a third party. They have a network of their own to couple storage to compute – and so do you, within your VM portfolio. They must be carefully set up to allow them to see each other and transfer data up to the cloud and back down again.

This is what's commonly called Software Defined Networking (SDN), and the funny thing about it – in the context of decluttering – is that most companies' manifests on big cloud platforms, consisting of piles of virtual servers linked by virtual kilometres of non-existent wires, are the very things the declutter manager has been tasked with finding and eliminating. ➔

That's because almost every tiny little virtual nut and bolt in your cloud sculpture has to be paid for, whether it's doing a useful job or not.

Nasty cabling

Ethernet cables are pretty resilient, but people tend to treat them as if they're actually indestructible. Perhaps this is a hangover from those pre-internet days when a network could be wrought out of thickly protected coaxial packages, and accessed with the help of a wickedly tipped metal-and-plastic "spike" adapter, making the Ethernet lead the most dangerous item in a normal office environment.

Modern network cables aren't dangerous, at least not in the same way: if you torture them by running an office chair wheel across them, they won't spark or smoke. But that doesn't mean the ultra-thin-stranded conductors inside them will survive unharmed. I've seen networks where fully 60% of the patch leads lying out on the floor or in the server room tested with some kind of failure.

The tricky part here is that a faulty cable – unless it's been completely severed – will still continue to work, sort of. Word will still save your documents to the server. Web pages will still load; video might be a bit intermittent, but it will mostly work, which makes definitive detection tricky. The really annoying part is that failing cables only become properly conspicuous when you're making heavy and repeated use of the connection, which is probably not the point at which you want to start refitting your infrastructure. I recommend businesses don't even bother investing in testing: take half a day to tot up how many cables, of what lengths, you're using, and then replace them wholesale from a large-scale cable supplier.

In fact, in the spirit of decluttering, I personally like to go even further. When practical, I advocate yanking every single patch lead out of every device, switch, phone, printer and server in the whole space, and installing fresh new cables only for connections I can personally verify are attached to a live, current, used connection. This is often an easy recommendation to sell to businesses – everyone likes to picture a tidy-looking data centre with a minimal number of nicely routed leads. It

also provides reassurance that there are no badly understood legacy devices hanging around on the network, exposing vulnerabilities and adding complexities that don't need to be there.

Going wireless

Wireless networking has its plus and minus points, but it can be a great way to reduce the amount of physical clutter in an office. The issue is to work out your traffic servicing priorities: there will probably be a long list of interested parties who want Wi-Fi, starting with (but not limited to) your own employees, customers, suppliers, delivery drivers, cabbies... and so forth. What you really want to do is keep them happy without handing all your bandwidth over to any schoolkid lurking just the other side of your fence.

However, while Wi-Fi may reduce the number of cables and switches on your premises, it probably won't let you get rid of them altogether. On the contrary, going wireless can add

complexity, as the kind of traffic and access management you're likely to need commonly involves using the wired network to federate Wi-Fi services together in the background.

To simplify things a little, posh configurations now use cloud-based, vendor-maintained control centres. I confess, having gone through various post-pandemic business continuity scenarios, that I don't see that the cloud-based multi-repeater model offers any fundamental advantage over local management, but the software is generations better than that on my youngest router, and that's worth quite a lot.

A final thought, on the subject of the pandemic: the abrupt switch to home working – whether temporary or permanent – will doubtless have resulted in an unmanaged clutter of documents held on shared servers and cloud storage, which is probably overdue a tidy-up and a clear-out. At the same time, owing to the weirdness of lockdown, IT managers have a tendency to mentally skip over the years 2020 and 2021, at least when thinking about the delivered value and age of work-from-home hardware and online services. It might feel as though we're still right at the start of the "new normal", but in fact we're now into year four – high time to be thinking about upgrades or supplier shifts. ●



ABOVE Cable service: it's always worth replacing old cables, faulty or not

Five things to take off your network today

1 Frayed cables

Can you see the little coloured internal conductors anywhere on a cable? In the bin with it, forthwith. Lots have transparent plastic plugs, held in place by a simple friction grip, so you can see the eight tiny leads through the plastic. If you see them anywhere else, such as through a rip in the outer sheath or at either end, then that cable is toast. Replacements are cheap and have real benefits for reliability and performance.

2 Low-speed hubs

The original building-block of twisted-pair Ethernet, these seem to combine complete dimwitted unmanageability with an eternal lifespan, so there are plenty of them knocking around to this day. They may still have a role if you want your internet connection to be attached to by several different devices, but the advantages of a proper network switch are becoming undeniable. At least try dropping in a decent modern switch in place of Old Faithful; you can always change back.

3 Cheap appliances using long-dead operating systems

One good example is those "embedded" CCTV systems whose appeal relies largely on flashy chrome trim rather than technical capabilities.

Most haven't seen a security patch in years and represent an appalling security hole, quite aside from probably clogging up your network. Don't worry about who bought them, or why – you have a responsibility to get them offline quickly and permanently. I recommend snipping the mains and data cables as flush to the casing as you can.

4 Powerline network extenders

These became popular in the 2000s, allowing small businesses to extend their networks without having to invest in proper cabling or grapple with newfangled Wi-Fi services. However, powerline data rates no longer cut the mustard, and some systems are also very insecure: it's much safer to put together a few bits of fibre-optic Ethernet and some hybrid switches, and your users will thank you for the huge speed boost.

5 Routers older than your phone

It may sound a bit mean, but it's a good rule of thumb. Typical Wi-Fi and DSL routers are by far the cheapest part of an SMB's mobile estate, yet they're typically replaced only once in a blue moon. Thus we get to the absurd position where employees' personal devices support 5G and Wi-Fi 7, while the company's infrastructure lags several generations behind. Do the right thing and keep up.



Employee engagement monitoring

Want to reward the best workers, and encourage the rest?
Steve Cassidy explores what engagement tools can do for you

Let me guess: is this using AI to keep tabs on our employees?

You're not far off, but the AI part is, in this case, optional. Employee engagement software is a class defined by its aims, rather than any particular technology, or indeed any industry sector. The key idea is simply to track the behaviour and performance of "good" and "bad" workers, and hopefully encourage the former with prizes and recognition.

So it does mean using technology to spy on workers?

That's an emotive way to put it, but not a wholly incorrect one. The vendors of these systems like to focus on supporting winners, but a key plank of that is giving managers enhanced visibility of what everyone's doing. And where there are winners, there will be losers – every league table has a bottom as well as a top.

Who are the dominant players in this sector?

There are a lot of platforms in the employee engagement space, many with clunkily constructed names such as Leapsome, Connecteam and Qualtrics. And there's no single market leader: the right fit for you will

depend on the industry you're in, the sort of work employees are doing and your own management style; that's why there are so many packages to choose from. Ultimately, a good indicator of suitability is when a tool maps onto your existing management structure and software portfolio without too much squinting.

Is all this necessary? What's wrong with a simple performance bonus?

Well, different cultures do things in different ways. One business I examined back in the hedonistic 1990s handed out bonuses to its advertising

executives in the form of small baggies of a mysterious white powder. Another company threw a big end-of-year warehouse party where every worker received a personalised mountain bike. The rewards were different, and you'd better believe the achievements they reflected were quite dissimilar.

Even so, do employee engagement tools help in a quantifiable way?

They can – as long as you pick the right product, deploy and implement it in the right way, and make sensible use of the data it collects. It's a good idea to take a targeted approach: these packages can extend their tendrils into all parts of your business IT assets, but one area where they work well is in simple manufacturing and customer-management industries, where you really can put a number on success. You shouldn't be needing to invent things to measure, or reasons to give out prizes.

If we're focusing on raw productivity numbers, what value does the package actually add?

Even if you're already tracking the important data, an employee engagement suite adds a formalised workflow, for both management and workers, to expose and streamline your employee reward system. That doesn't just improve your competitiveness by aligning your employees' incentives with the company's goals; if it gives them a realistic way to shoot for decent rewards, it can help attract higher-quality employees to do the work.

Would you want to be watched over by one of these systems?

Selling employee engagement tools to the workforce can be a challenge – but again, if you're worried that it will start a mutiny then that could be an indication that you're trying to promote the wrong things. The ideal is to drive low-risk, low-impact changes to your workflow that yield worthwhile rewards. ●

Engagement goes both ways

Almost all employee engagement tools include some sort of analytics, to track when workers log in and out, what applications they're using, what websites they're visiting, who they're emailing and so forth. But it's not just about surveillance. Many suites also include intranet-type features to help employees feel engaged and motivated, such as:

■ **A central news page** that helps employees stay informed and connected with what's going on in the company – although of course this only works if you keep it regularly updated.

■ **Discussion groups** that let employees feed back what's working for them and what isn't; this not only makes them feel heard, it can yield valuable insights from the front line.

■ **A goal tracker** that ensures everyone knows what their targets are, and provides a way to track their progress towards rewards and bonuses.

■ **Official forms and documents**, so employees can check up on policies and procedures for themselves, rather than being beholden to intermediary managers or HR representatives.

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Real world computing

Expert advice from our panel of professionals

JON HONEYBALL

“I have lost confidence in Twilio. If it will do this to customers, then what might it do next?”

Jon, aka Disgusted from Tunbridge Wells, turns his wrath on Twilio for how it's treating its customers, and shakes his fists in the direction of Three

Authy has long been my go-to app for all things two-factor authentication (2FA) because it runs on everything – all my desktops, my iPhone, my iPad and my Android phones. It's super easy to use on the desktop: keep the app open and I can have a 2FA six-digit code with a few mouse clicks. It even copies the code onto the clipboard, so pasting into a site couldn't be simpler.

Last month, I wrote of my displeasure with Authy as it had decided to close down the desktop apps later this year, and how this would make me reconsider its use. I have a workable solution, as the iPhone/iPad app will work on an M-processor Mac desktop, giving me some continuity. But my primary desktop in the lab is a 2018 Mac mini running a six-core Intel Core i7 processor. Not the fastest CPU any more, but 64GB of RAM helps, as does the built-in 10GbE port. It still does sterling work, but I was always going to move to an M-based Mac mini during 2024 if and when Apple launched one with an M3 inside. I'm hoping they arrive soon.

So I have actually got a route forward for my primary desktop, without resorting to finding my phone to look up a 2FA and then manually typing it into a website.

However, when Authy announced that the app would go unsupported on 19 March rather than during the autumn – with no reason given for this change – it gave me only a few weeks to consider my options. I could keep using the desktop app and accept that it's unsupported: this

probably wouldn't matter for a while, but 2FA is a core security component and it seems rather naive to run something that's unsupported. Or I can rush out and buy a Mac mini before I want to. I will probably do the former.

But I am furious at Twilio for bringing forward the end-of-life date for the desktop app to a few weeks. The original autumn date gave a deadline that customers could work to. A few weeks is an insult.

Because of that, I have lost confidence in Twilio and its Authy product, despite my love of it in the past. If it will do this to customers, then what might it do next?

And that, dear reader, is how you implode your platform.

Three prices

I have a bunch of SIMs on Three. You may remember the pain I suffered trying to get these set up, when it became abundantly clear that the Three store in my local town was incapable of supporting the Three business product. And how Three managed to not enable international roaming despite it being part of the setup. And how I discovered this when I got off the ferry in France. Thank goodness I had a second eSIM in the phone from a different supplier who had a more robust setup process.

I have also told you about how Three managed to overcharge me for three of the SIMs (I guess that's poetic justice) to the tune of over £800. And that it then promised to refund



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[X @jonhoneyball](#)

the money after much wrangling, and then simply didn't.

The first three of those ten SIMs are coming up for renewal. It's currently £10 per month per SIM for unlimited data and calls – a typical multi-SIM business rate. Out of contract, the price will be £10 per month per SIM. Or I can renew on a 24-month contract for the grand sum of £18 per month per SIM.

A quick look at Three's website suggests, however, that a three-to-nine SIM business plan is £10 per month per SIM, while a ten-to-15 SIM plan is £7.50 per month per SIM. So I am unsure where this £18 per month comes from, unless Three is viewing these three SIMs (of my ten) as being single SIMs. Which is just stupid, but par for the course for my experience with the company.

I think it's high time to look elsewhere, and to get PAC codes for the important numbers.

At least Three has been consistently poor over the life of this contract. Maybe we should rename it Two instead.

BELOW SIM pity: my travails with Three have led me to look for another provider





Jon Honeyball

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Lee Grant

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Dr Rois Ni Thuama

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Davey Winder

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Steve Cassidy

The wider vision on cloud and infrastructure – p120

eSIM for USA

Talking of SIMs, you will recall that three of us (me, Tim and Barry) went gallivanting off to Las Vegas in early January for CES. We even did an episode of the *PC Pro* podcast from my hotel room, a tradition we try to uphold.

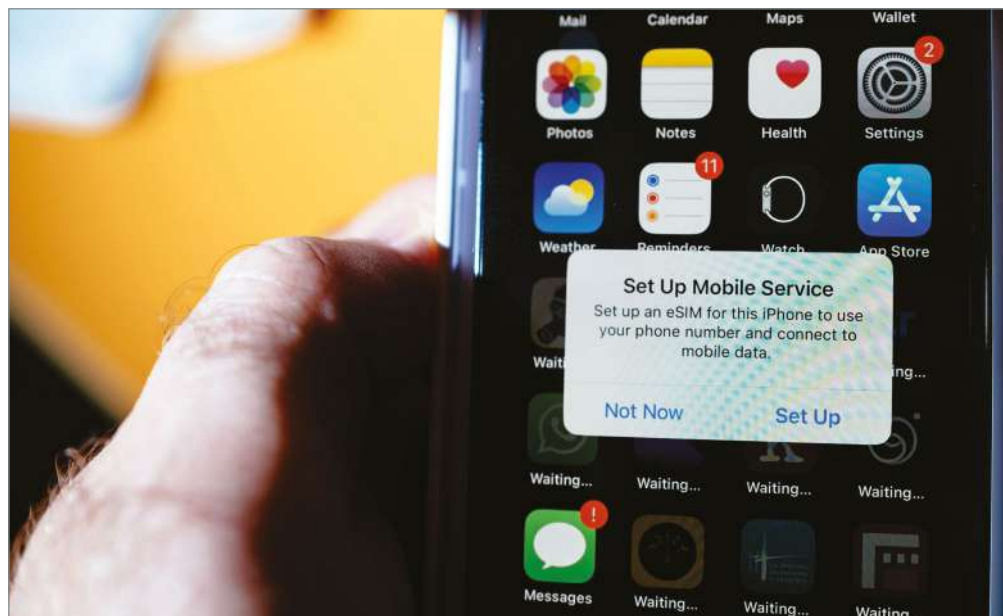
Although I could have paid the international daily roaming cost for Three, I decided to have another go at eSIMs. In the past I've used T-Mobile in the USA. It has an excellent app that you let you choose the plan you want, and it generates and downloads the eSIM to your iPhone in a matter of seconds. Ensure that the eSIM is enabled as your second line, turn off roaming for you first primary SIM, and you're up and running. A T-Mobile eSIM gives you a temporary USA phone number and up to unlimited data, including 5G.

Getting a temporary USA phone number in the past did have value. Some restaurants require a phone number to confirm a reservation, and get very confused when they discover you are from Somewhere Else. But that's quite rare now.

However, a temporary number can be awkward if it has been reused recently and a previous tenant has signed up services to it. I have heard many, admittedly apocryphal, stories of people finding their WhatsApp linked to someone else's account. It hasn't happened to me, but that's the sort of frisson my life can do without.

So a simple data-only plan seemed to fit the ticket. In the end, I went with a global service called Holafly. It was €69 for unlimited data for a month – maybe a little pricey, but I didn't know if I had to return to America during January, so a month's time span seemed reasonable. To get the SIM, you just fill in a web form, and then a QR code is emailed to you. In the phone, go to the eSIM settings area, choose a new SIM, scan the QR code, and it loads it into the phone. Don't enable it until you actually land in the USA, because the 30 days starts from the initial switch-on.

What can I say? It just worked. I landed in Los Angeles, enabled the SIM and switched my data connection to the new eSIM. For the rest of the time in the USA, all of my data routed over the eSIM. Of course, this also



included all the VoIP traffic from our lab 3CX phone switch, so all business calls routed over the eSIM connection, too.

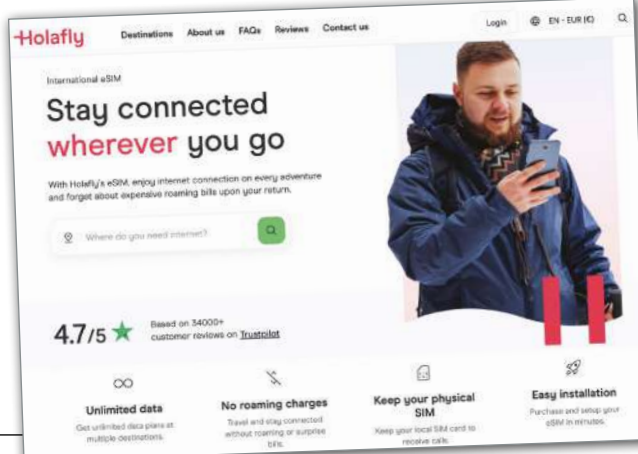
For the money, I might have just paid for roaming. But at least there was no sign of any "fair use" cap on the so-called "unlimited data" that UK carriers like to apply. Looking at Three's website, it is clear that "Unlimited data can't be used abroad. You can use up to 12GB of your allowance if you're in Go Roam in Europe and Go Roam Around the World destinations."

Now 12GB might seem a lot, but it really isn't. I could buy a "Data Passport" on a daily basis, but frankly this is a lot of hassle. Holafly offers packages in the USA at €19 for five days, €27 for seven days, all the way up to €99 for 90 days. I'm back

ABOVE Setting up an eSIM for my trip to the US was simple

"It's now a buyers' market, with a pile of companies offering eSIM services"

BELOW Holafly's eSIMs worked well for me in the USA



in the USA in April for a week, and will almost certainly pick up a ten-day plan for that trip before I go.

Clearly it's now a buyers' market out there, with a pile of companies offering eSIM services. Maybe a different firm is better or cheaper than Holafly, but all I can do is report that it worked fine for me.

How many eSIMs?

Given the topic of eSIMs, I was naturally curious to find out how many eSIMs I could actually load at once. Not that I need lots, but it's a nice thing to know.

My iPhone 15 Pro Max runs with a physical SIM from Three and an eSIM from EE. The reason I have the second SIM is because I was interested to see how that worked.

And at the time, EE was one of the only providers that supported Apple Watch on an eSIM. I'm sure that has changed now.

So adding in a second eSIM would take my count to three. No, not Three. Keep up at the back.

Turns out that a modern iPhone can support up to eight "or more" eSIMs, giving you a huge range of choice. I can't imagine anyone needing that many, but it is possible to load them up. Up to two lines can be live at once, and both associated phone numbers are live as well. You choose which current



connection is used for data. I sometimes find it useful to switch to the other sim when I find myself in an area with weak data coverage on my primary sim, although I would confess this is most definitely a first world solution to a first world problem.

If you have an LTE-supporting Apple Watch, then you can put up to five eSIMs in the Watch. However, an Apple Watch can only have one SIM live at a time, which is really not unreasonable.

I tried to find out how many eSIMs I could load into my Samsung Galaxy S24 Ultra. It seems that it can certainly take two, alongside a physical sim, giving a total count of three. But I can't find anything to suggest that you can rack them up like an iPhone – it might be possible, but I can't find any documentation. However, the reality is that two eSIMs is likely to be just fine for any normal customer.

Power to the (2.5Gb) Ethernet

I bought one of the new UniFi U7 Pro (tinyurl.com/356unifi) Wi-Fi access points to see how well 802.11be, aka Wi-Fi 7, would work with the first wave of BE devices such as the Samsung Galaxy S24 Ultra.

You'll recall that I like the UniFi platform for networking and Wi-Fi. It's not to everyone's taste, being a closed system, but it doesn't suffer from the "pay the subscription or it all stops working" that I had with Cisco Meraki. And I really do like the centralised management console for all the devices; it makes configuration so much simpler, and infinitely nicer than the face full of meaningless nonsense you get in a lot of Wi-Fi mesh products from the more domestic-oriented vendors.

So I bought a couple at the grand price of £143 each plus VAT, replacing our U6 Enterprise access points. Not that there's anything wrong with the U6E: it supports the

6GHz band as well as the usual 2.4GHz and 5GHz, and it has 802.11ax support, too. So it's pretty solid and well equipped, now that AX has been around for a while.

BE, being entirely new, was always going to be somewhat bumpy. However, I needed to know just how bumpy and what was on offer in terms of performance today, so I could watch the improvements over the next year.

Now the U6 Enterprise is, like any decent wireless access point, powered directly from the Ethernet cable via the power over Ethernet (PoE) protocol. I only have 1GbE-powered

Ethernet ports on my switches, so the connection will only run at 1Gbit/sec, not the potential 1.8Gbits/sec that we regularly see in our performance testing rig, which uses a Netgear RAX200 and RAX500 routers (in non-routing configuration).

But the U7 Pro needed to go into that test environment, so I needed to use 2.5GbE switches at the very least, and that meant having 2.5GbE ports with PoE+ on as well. These are not as common as you might think, and I didn't want to use PoE inline injectors, preferring to keep things clean and simple.

Clearly another shopping accident was required, and I chose the UniFi Enterprise 8 PoE switch at £383 plus VAT (tinyurl.com/356unifi2).

This has eight 2.5GbE ports with PoE+ so is perfect for driving the access points, while two 10GbE SFP connectors are perfect for using a short 10GbE SFP cable to the primary switch in the test rig. These are extremely cheap at £10.40 for a one-metre length (tinyurl.com/356unifi3) and ideal

for interconnecting core networking devices. I also have a pile of SFP-to-10GbE Ethernet adapters (tinyurl.com/356unifi4), which are a little pricier at £52 apiece, but allow you to use high-quality Ethernet cabling. Or go direct to a long length of fibre with SFP-to-fibre adapters at £30 each (tinyurl.com/356unifi5).

So now I had the U7 Pro connected up to a 2.5GbE PoE+ switch, connecting to the lab test backbone at 10Gbits/sec and hence into the local test server, which uses Intel 10GbE PCI cards.

I connected up the S24 Ultra and ran the throughput testing tools. Now I know this is good for the full 10GbE speed at nine point something gigabits per second of user data. Likewise for around 1.8Gbits/sec on 5GHz Wi-Fi 6 (AX) with the full 160MHz channel width. The best I could get on the S24 Ultra combination with the U7 Pro was [drum rolls] just about the same.

I'm not sure where the bottlenecks are: it might be the Samsung phone, it might be the UniFi access point. But it's abundantly clear that this is not delivering any of the promised performance that is claimed by the Wi-Fi 7/802.11be cheerleaders. The performance isn't in any way bad,

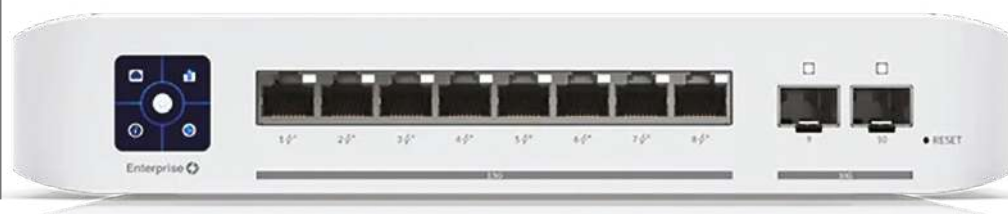


ABOVE You can put up to five eSIMs into an LTE-supporting Apple Watch

"Wi-Fi 7, being new, was always going to be bumpy. I needed to know how bumpy"

LEFT The UniFi U7 Pro was underwhelming when it came to Wi-Fi 7

BELOW The UniFi Enterprise 8 has eight 2.5GbE ports with PoE+



but it simply isn't any better than 5GHz 802.11ax when done properly.

Let's be generous and say that it's very early days for the 802.11be specification. That all the vendors are doing interoperability testing and furiously improving their firmware. And that exactly the same thing happened for the first year or so of AX, which was a horror show if I may retain my generous nature.

Eventually AX settled down and is now a solid solution. I'm sure Wi-Fi 7/BE will get there, but I certainly wouldn't consider buying this kit from any vendor this year. And I must put in the obvious rider: you need to connect your Wi-Fi access points on an Ethernet backbone that's running at a minimum of 2.5GbE speed. And if you're connecting to the wider internet, ask yourself how fast your WAN connection is. A top-flight 1Gbit fibre connection is going to be the limitation here, even for good AX today, let alone the sunny uplands of BE next year.

If we're not careful and the bugs aren't ironed out, we might get yet another 5G overpromise and underdeliver disappointment.

Ultra dead

My shiny new Samsung Galaxy S24 Ultra has just died, and it wasn't due to too much Wi-Fi testing. I was using Samsung's rather nice Smart Switch tool, which lets you connect the phone to your desktop to drag and drop files. My previous choice, Android File Transfer, is now creakingly old and often doesn't connect.

Smart Switch said that the phone needed a software update. Somewhat surprising, because it appeared up to date on all apps and the OS, but what could go wrong? I told it to run.

This update process then crashed, leaving the phone with a blue screen of death. On advice from Samsung's support team, I booted the phone into Recovery mode, followed by a clean of the cache. This didn't work. So we did a full factory reset. This didn't work, either. Now I'm left with a phone that boots, shows the splash screen, and then reboots again. And again. And – you get the picture.

It's being collected tomorrow by courier to go to a Samsung service centre. Who knows if it will return?

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LEE GRANT

"My kids are able to handle tricky situations, even ones inadvertently caused by their own father"

While one man struggles to retain his "World's Best Dad" mug, we discuss the London Underground's laptop diagnosis technique

"Dad?" I knew by my daughter's intonation that something was amiss. "Why is this naked lady eating a huge sausage?" I didn't get the chance to answer before her younger sister popped up, looking equally baffled. "Why is the aubergine emoji funny?" Screens emerged showing a chat app with lots of (seemingly) young kids gabbling away courteously, interrupted by a couple of trolls, keen to demonstrate their loquacious wit with four letter put-downs and a sizeable collection of porn GIFs. Let me explain.

One item I recommended in the *PC Pro* Christmas gift guide was the Divoom LED Bluetooth speaker (see issue 352, p26). It's a fun device with a powerful companion app, allowing users to create vibrant designs and animations that appear on its 16 x 16 LED display. My daughters both acquired a Divoom during 2023 and happily passed time noodling away with its features. Naturally, in 2024, if you're not sharing your life online with someone somewhere to make money out of, then you're a loser, so the kids asked if they could upload some of their designs into the chat feature. I said yes, removing the Kids Mode restrictions.

Via the chat, you can share, rate, review and download designs to run on your own Divoom. Some designers have gained a sizeable following and, in many respects, there's a mini-social media aspect to the community. An occasional troll trying to spoil the vibe is nothing unusual, yet like the larger platforms, Divoom seems to have a moderation issue.

My daughters and other users have used the block and report features to silence the trolls, but the offensive messages remained in the stream and the trolls could keep on posting.



Lee Grant and his wife have run a repair shop in West Yorkshire for over 20 years
@userfriendlypc

"Like the larger platforms, Divoom seems to have a moderation issue"

BELOW The Divoom LED speaker is fun but unsuitable for kids when unfiltered

From the content and language being used, there was clearly no form of rudimentary text filtration in play to block offensive terms. I reached out to Divoom support, sending a bunch of screenshots, and received a response the following morning. "We're os [sic] sorry dear that I didn't find the messages. Could you check it again and tell me the exact date? I will check and delete now." Not the most reassuring support message I've ever received.

As I've confessed, this was my fault. Divoom's Kids Mode enables a grown-up to restrict access to elements of the platform, including private messaging, group chats and comments. When I'd disabled the feature, I honestly think I'd been under the delusion that Divoom was more kid-focused than it is and I'd presumed that certain safety rails would be present. There's no doubt Divoom's branding is quirky. I'm no marketer, so the best I can say is that it's targeted at a younger audience, but on reflection, I can now see that it is not exclusively a "kids' brand". For example, the Divoom Ditoo-Pro speaker has the strapline, "Keeping your Workspace Interesting", which on the evidence of some of the more esoteric animations I'd spotted could certainly be true.

I asked Divoom to clarify its moderation and filtering system, and it replied: "Our Divoom app has our official customer service, Dida, who is responsible for answering questions and maintaining community health. Our company and staff are in China. When there are unhealthy comments in the group, our staff are in break time. We're very sorry for not being able to handle it immediately. Yesterday, our Dida immediately blocked accounts that spread unhealthy information and images after going





to work. We're really sorry for the bad user experience you had. In the future, Dida will respond more promptly to customer inquiries and handle negative information within the group, providing users with a healthy and friendly community environment."

Evidently, Divoom's moderation is largely a manual process, which one imagines is complicated when volumes of users simultaneously hit the platform.

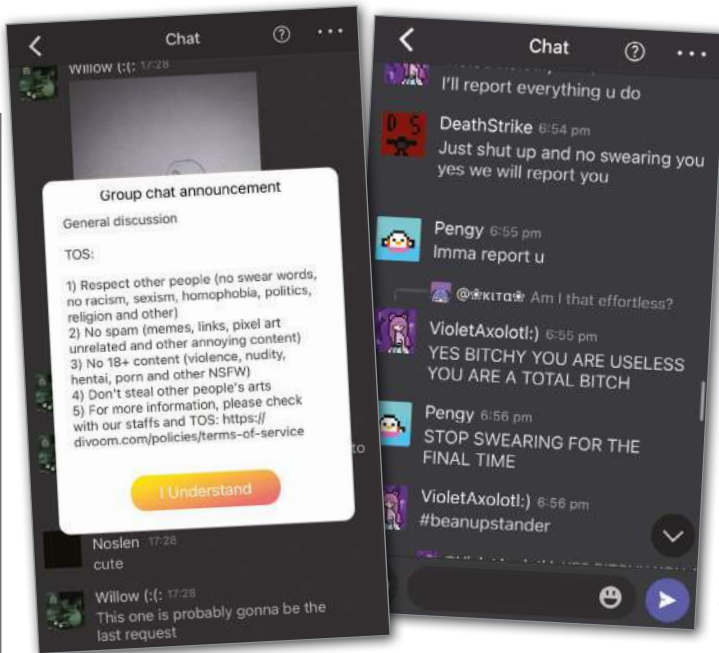
Readers with long subscriptions – please visit subscribe.pcpro.co.uk to join this exclusive club and indeed gain access to digital back issues – may recall I mentioned internet safety lessons in schools in issue 312, including Google's Internet Legends (tinyurl.com/356legends). Most KS2 kids are drilled in what to do when they see things online that they don't like. My kids' frequent teatime stories of "you'll never guess what Sadie shared on her brother's phone" are chances to continue this dialogue. Open, age-appropriate conversations about online risk, over-sharing and cyber-bullying have embedded something into them, so they can handle, process and discuss tricky situations. Even ones inadvertently caused by their own father.

This incident has been a reminder that as my children grow up, and we slacken the parental controls and network filtering protections, that I need to take time to gauge where their next platform of choice sits in the grey area between the cosy child-friendly environment of CBeebies and the wild-west of CBoobies.

Fairphone continues to lead

At the end of January, Fairphone put smiles on the faces of repairers by releasing the schematics for the Fairphone 5 smartphone. If you like an electrical diagram, admire the comprehensive documentation package the company has released at tinyurl.com/356fairphone.

For the uninitiated, schematics are akin to maps in that they utilise graphical symbols and lines to represent elements and connectivity of an electrical system. A useful comparison is the London Underground map, which also uses lines to represent different routes and dots to represent connections



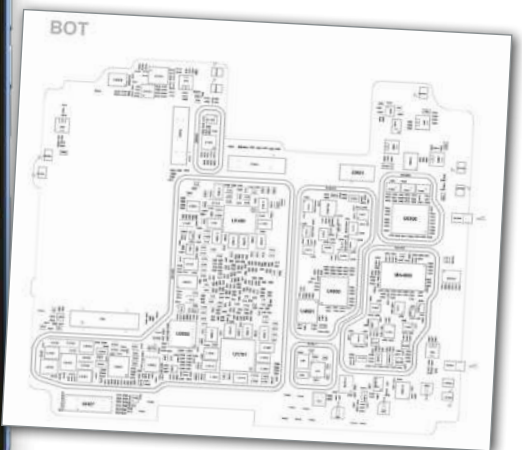
ABOVE Trolls are ruining the chat feature in Divoom

"Schematics reveal the secrets of a device, which is why modern manufacturers keep them under lock and key"

BELOW The Fairphone 5 makes repairers' lives easier by making the schematics public

between the stations. Also like the Tube map, schematics may look nothing like how the circuit appears in a physical form; it's purely a way of documenting how the components in a circuit connect. Schematics reveal the secrets of a device, which is why modern manufacturers keep them under lock and key.

Previously, Fairphone published the schematics for the Fairphone 4, so it's encouraging to see it continuing to lead the entire smartphone industry in terms of reparability. I asked Miquel Ballester, head of product management at Fairphone, if publishing this information had been a challenging decision. "It is indeed a matter that divides people, but ultimately, we believe that it is in line with our innovation strategy to be as transparent as possible as long as it contributes to the longevity and reparability of our products."



Ballester also explained why schematics for Fairphone's entire range haven't yet been released. "We don't have a particular reason for this, it just takes work that we cannot prioritise in the short term. Customers are, however, always welcome to contact us for specific questions."

A matter of schematics

To give you an example of the importance of schematics, let's talk about Jamie's laptop, which wouldn't charge.

Luckily, he spotted this before the battery had fully depleted, switched Windows into low-power mode and offloaded critical files. A smart move, showing a keen sense of urgency, which is tragically ironic as, when I took the machine from him, I immediately pointed out that it rattled. "Yes," he laughed, "it's done that for months."

I gently pointed out that a random rattle is not a standard feature of most laptops and asked if he'd noticed anything else before it stopped charging. "Only the burning smell." You can decide for yourself if you think Jamie would have persisted with his rattling, umami-scented laptop if the charging problem hadn't occurred.

Jamie's reliance on his laptop for work means he's naturally reluctant to be without it (many people are), but short of evolving the ability to speak, his laptop has made considerable efforts to raise the alarm that all was not well.

Inside, the problem was obvious, though the solution was not. One of the internal hinge screws had come loose and was the cause of the rattling sound within the chassis. Its ultimate

resting place was wedged over various contact points of the USB-C socket, where it had caused a short-circuit. At some point, and I'm not an electronic engineer so cannot fully explain, the power running through the screw had generated enough heat to destroy a surface-mounted component slightly downstream of one of the many tracks leading from the USB-C socket into the bowels of the laptop.

This would have been an easy fix if I could access the manufacturer's schematics. I could locate the corresponding part of the circuit and find a jumble of alphanumerics, which would tell me what type of component Jamie had inadvertently cremated. It could be a smoothing capacitor to filter out DC noise or perhaps an Inrush limiter to save the laptop should the charger have a mishap. Who could tell?

I've watched YouTubers solve these issues by soldering a piece of wire between the terminals, which resolves the symptom but may have serious implications if things go badly wrong. Central to every repair I do is customer safety, and if my dodgy electronic repair is deemed the reason a customer's house burns to the ground, then I'm culpable. My conscience will not allow me to guess what the burnt component was, because if I got it seriously wrong, and weeks later the bodge goes seriously wronger and lights up the customer's battery in the wrongerest of ways, then we're all in a lot of trouble.

Classic Tosh

Publishing schematics used to be common. My first tech job as a teenager was fixing arcade machines in the seaside town where I grew up. If you remember the arcade classics of the 1980s and 1990s – Out Run, Star Wars, Street Fighter – then allow me to reveal that shoved inside the heavy wooden cabinets, alongside the keys to the cash-box, was a full schematic for the machine. Like many electronics of that era, the manufacturer was happy for you (or the local electronics shop) to fix the product that you owned.

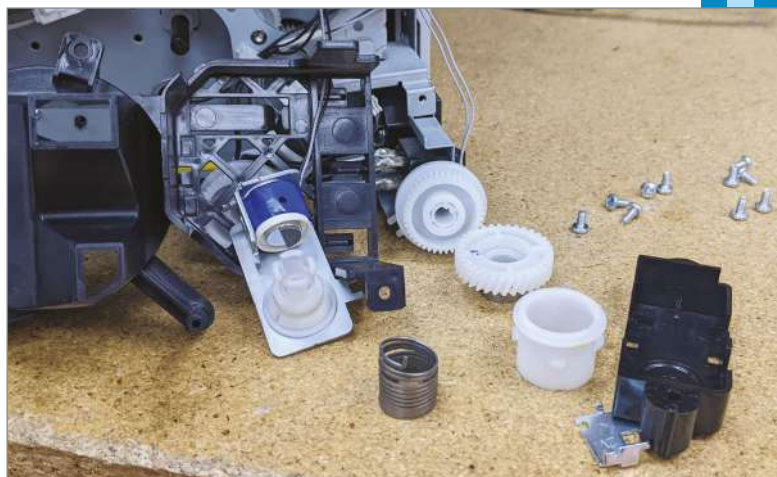
Several months ago, an ancient Toshiba C660 laptop arrived for diagnosis after the customer reported it wouldn't switch on. I put the motherboard under the microscope and checked for vital signs with a multimeter, noting that the board received power at multiple points. As this was an old Toshiba, I rummaged down the back of the internet sofa and pulled a schematic from a website that definitely didn't belong to Toshiba.

From this, I traced the fault to the machine's power management IC, where I spotted a burnout under the chip near to the input pin. This IC was less than 8mm², so the fault was undetectable to my naked eye, and I'd also missed it while under the scope. Removing the chip revealed quite a lot of track damage, which would need to be repaired before the IC was replaced. Ultimately, the customer decided against the repairing this Windows 7 machine, but my intention is to use it to improve my skills at track repair. I'll let you know if I get it to squeak into life again.

A step printer the unknown

When Right to Repair advocates talk about wanting access to the manufacturer's documentation, schematics are part of that demand. Another vital piece of documentation is the Field Service Guide (FSG). Many laptop manufacturers supply these and some are very clear and comprehensive. A good FSG gives explicit steps on how to remove certain components. For example, if you want to upgrade the SSD, it will explain how to remove the back cover (often with screw sizing guides) and every other component that physically needs shifting before the drive can be accessed. HP has improved the format and made video versions, which is a brilliant move for the PC industry to follow. Sadly, I can't say the same for the masochists who make HP's printers.

Caroline's laser had a common show-stopping fault which has a comically low-tech solution. When a printer powers on, there are several minutes of whirring, coughing and clicking before it will do anything entertaining. Caroline's laser spluttered to a halt during startup



ABOVE A printer with a faulty clutch can be a tricky beast to fix

"I felt the cold sweat of a surgeon who fears they've just removed the wrong leg"

BELOW The detritus at the bottom of this printer was a mystery to me and the owner



and then sat there with a smug grin, flashing a nonsensical error code to the world. When I'd passed this into the Rosetta Stone, it led me to diagnose a faulty clutch (yes, printer have clutches, often more than an F1 car).

What followed was hours – and I mean hours – of experimental teardown to remove security headed screws (why?), springs, cogs and PCBs. I photographed and documented each step as a breadcrumb trail, which I hoped would allow me to rebuild the damn thing. Many times, I experienced a terror that I'd removed the irreplaceable and felt the cold sweat of a surgeon who fears they've just removed the wrong leg.

The fault was a tiny piece of plastic foam, which should be at one end of an actuator, but because of heat had slid to the other. I removed it, put it back and affixed it with heat-resistant Kapton tape. Once rebuilt (I still wake up screaming about misaligned feeder sensors), it worked once more. Printer FSGs are much harder to find than PC versions as manufacturers don't publish them because of the long established and outrageously profitable business model of printer maintenance contracts. I'm hopeful that #RightToRepair will change this.

How to wreck an inkjet

Finally, a mention for Sue's Epson EcoTank, which came in with a paper-feed problem. Using the latest advancements in repair diagnostics, I inverted the device and banged very hard on the underside. Out fell paper shreds and an unidentified rubber foot.

A glance at the paper exit revealed a fibre of rubber that, when coaxed with tweezers, belonged to an elasticised luggage tag. Sue looked at me with genuine surprise. "How did all that get in there?" A simple question, but one I could not answer.

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ROIS NITHUAMA

“The cybersecurity sector is already noisy, and it’s going to become noisier”

The rapid rise in AI tech against the backdrop of geopolitical turmoil provides unique circumstances that businesses need to navigate with care

In the history of human development, we have never seen such rapid technological advancements as today. Even the Space Race doesn’t compare; few had access to that technology, so the rest of the world merely observed.

This acceleration in technological progress would be tricky to navigate during peaceful times, but this rapid innovation is unfolding simultaneously with ongoing geopolitical tensions. Open warfare continues to rage as Ukraine battles fiercely to defend itself from Russian aggression. The threat of war spilling over into other parts of Europe became a pronounced concern when the Danish defence minister warned that Russia could attack NATO in three to five years. The Prime Minister of Estonia is on record estimating a similar timeframe. The death of Alexei Navalny, the Russian political activist, shows an increasingly erratic despot with everything to lose. Things are about to get real.

If we merely needed to worry that Russia’s continued aggression against the west could play out in the physical world, we’d have enough to deal with.

But we must consider this against other “known knowns”. Last year, the National Cyber Security Centre issued an alert to critical national infrastructure (CNI) organisations warning of an emerging threat from state-aligned groups, sympathetic to Russia’s invasion of Ukraine. At the beginning of this year, the World Economic Forum warned that: “Increasingly alarming attacks against critical infrastructure, and elements in global supply chains, coupled with economic instability, have the potential to cause macro-impact.”

This increasingly tense geopolitical situation merely forms the backdrop.



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“The fast-paced progress in AI and ML is giving rise to new, untested solutions”

BELOW The death of Russian activist Alexei Navalny in February shocked the world

It will create the conditions for businesses to look to protect themselves in more robust and cost-efficient ways for their own business and their supply chains. Business decisions will need to be made quickly and efficiently. Having the right information to hand will help to avoid costly mistakes.

Against this backdrop, the extremely fast-paced progress in AI and ML is giving rise to new, untested solutions. Some of these solutions will work, some will not and those that don’t are going to create additional legal and operational headaches.

Business must grapple with three pivotal considerations in this new normal:

- The influx of seemingly innovative yet unproven technologies is going to make an already noisy sector much noisier.
- Some of the new technology won’t work as described or promised.
- Some of these new technologies will breach the rights of others, including employment and patent laws, leading to more litigation.

Turn it up to 11

The cybersecurity sector is already noisy, and it’s going to become noisier as the sector is set for continued growth. Hardly surprising, given that the cost of cybercrime to the global

economy is calculated to jump from \$8.15 trillion in 2023 to \$9.2 trillion this year. Throw political instability into the mix and we’re going to see more solutions in the market.

The appetite to protect businesses and preserve their assets will be considerable. Implementing tools that will protect the firm and/or reduce costs will need to be investigated.

Of course, many companies will legitimately frame their solutions against the real threat posed by nation states, while others will undoubtedly surf the current conditions, exploiting the real sense of urgency and the new defensive posture that directors must assume to avoid losses and protect their firm. So what can be done to guard against this?

At a very basic level, tyres must be kicked. If a vendor claims that X is a problem, ask it on what basis it has drawn this conclusion. If the vendor’s statement induces your business into a contract or agreement based on something knowing that it was false or without believing in its truth, it could be misrepresentation. If you’re induced into an agreement based on statements made by the other side, even if that representation doesn’t make it into the four corners of the final contract, you could have recourse to remedy. Statements made in the pre-signing phase are material. Ask lots of questions and make sure to keep extensive contemporaneous notes.

Useless or worse than useless

When it comes to tech (hardware or software) that doesn’t work, there are, in my opinion, two types: useless and worse than useless. Useless is a toaster that won’t make you toast; worse than useless is a toaster that burns your house down. Instead of delivering on the promise of fixing a problem, worse than useless kit becomes a problem.

If it’s just useless, you’ve lost (i) the cost price, plus (ii) the research and negotiating time invested in procuring the kit, plus (iii) the disruption caused by downtime because the kit failed to do what it was supposed to do, and possibly (iv) the drop in productivity because it negatively impacts staff. The cost of getting it wrong can bite.

But if it’s worse than useless, it goes beyond direct economic losses. There have been a few cases that have received media attention recently, and one in





DAVEY WINDER

“This is a big player, the most active ransomware group, taken down in a big way”

The takedown of LockBit ransomware not only puts that group’s future in jeopardy, it teaches all of us some valuable lessons

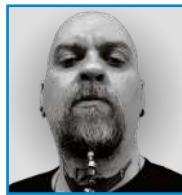
In the long distant past, when I wasn’t even three decades old, I was a hacker. To be precise, I explored online networks without permission, being very careful indeed not to break them, in order to learn more about the emerging connected world.

What I didn’t do was think it would be an excellent opportunity to steal data or blackmail people using whatever I might have stumbled upon. It would never in a million years have occurred to me to go and try to take a hospital offline or grab a load of patient data before locking down the original until half a tonne of cryptocurrency was sent in my direction. But then I am not, and never have been, a profit-driven arsehole who doesn’t care about the harm they cause or to whom that harm is caused.

Criminals who target hospitals are the scum of the earth.

The same can be said for cybercriminals who partake in ransomware attacks. These scumbags really are the lowest of the low. As someone with complex health issues myself, I know only too well how hard everyone who cares for me works, many with very little reward in terms of their salary.

As I write, around 100 hospitals in Romania are recovering from the impact of a ransomware attack against a supplier that delivers managed IT systems to healthcare using the Hipocrate platform. Some ransomware groups have tried to take the moral high ground – oh, the absolute irony – by saying their “rules” forbid associates from attacking healthcare targets. Yet most of these have also downed hospitals or clinics, crying about collateral damage or rogue associates



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“Any attack that prevents or delays treatment endangers life. Simple as”

when the law enforcement pressure is upped, and the media paints them for what they actually are.

Some, such as LockBit, do “allow” for attacks against healthcare and pharmaceutical targets, but on the basis that – can I say “oh, the irony” again? – the attack must not endanger life. Any attack that prevents or delays treatment, be that medical, surgical or pharmaceutical in nature, endangers life. Simple as. Although the criminal group behind the Romanian attack has remained unnamed at the time of writing, it’s clear that it knew exactly who it was attacking. Some 25 hospitals were impacted directly by the ransomware, while another 79 took their systems offline as a precautionary measure while investigations into the attack continued.

Unusually, the Romanian ransomware attack doesn’t appear to have exfiltrated any data. It’s unusual as this is the most common route that attackers take these days, holding destruction, publication or sale of that data to ransom. The ransom demand of around \$100,000 in Bitcoin is also unusual in that it’s on the low side, to say the least, for such an attack. All of which suggests to me that this could be a relatively new ransomware group.

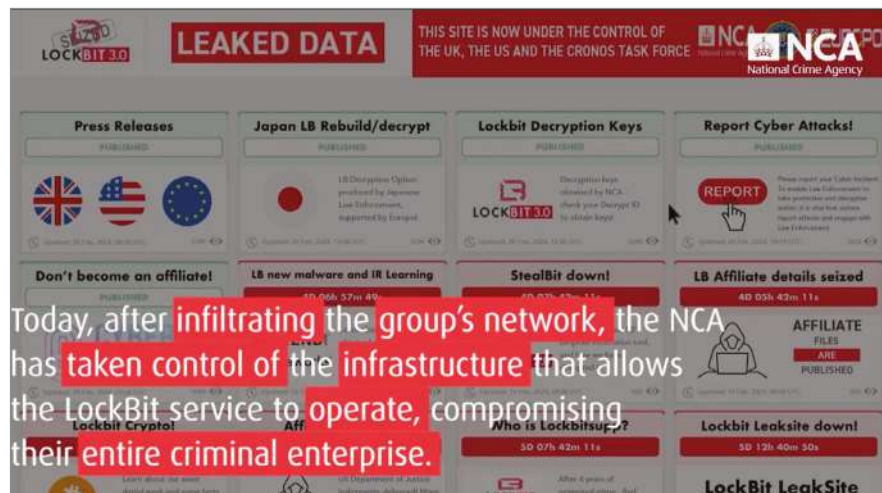
Whatever, I hope it suffers the same fate as the aforementioned LockBit gang, whose infrastructure has been seized in a joint operation led by the UK’s National Crime Agency with cooperation from the FBI and Europol.

LockBit gang down, but will they stay out?

Operation Cronos has been successful in taking control of LockBit’s infrastructure and, importantly, data behind the group’s data leak site. I must admit that I did chuckle and raise a glass to the NCA operatives who replaced LockBit’s data leak site information with a superb trolling display of member arrests, links to decryption keys and an offer of \$10 million on the head of the group’s admin. But, more seriously, this is a big player, the most active ransomware group for the past two years running, taken down in a big way. I’ve been speaking to members of the security community and it’s worth reading what they have to say as it’s very on point.

Let’s start with Chester Wisniewski, director and field CTO at Sophos. “The work of the UK’s National Crime Agency (NCA) and their international partners has delivered a severe blow to the world’s most prolific criminal ransomware syndicate,” he told me. “This is the most insight we have gained into how these groups operate since Conti’s implosion in May of 2022. The decentralised nature of these groups makes them particularly difficult to track down.”

Wisniewski also said that law enforcement has acquired access to the encryption keys used to lock up victims’ files and will provide them to help with recovery. Unsurprisingly, and it’s something I’ve been warning



RIGHT Operation Cronos took control of LockBit’s leaked data site

Today, after infiltrating the group’s network, the NCA has taken control of the infrastructure that allows the LockBit service to operate, compromising their entire criminal enterprise.

organisations about for the longest time, Wisniewski went on to say that the exfiltrated data of those who paid a ransom to have it deleted – so it supposedly couldn't be published or sold in future – wasn't actually deleted at all.

Wisniewski doesn't, however, expect LockBit "to make a triumphant return". Instead, he points to those that have been disrupted before and rebranded "under different banners to continue their ransacking of innocent victims' networks and take on name identities to evade sanctions".

Mark Stockley, senior threat researcher at Malwarebytes, also considers the "unanswered question" of "how much of LockBit group is left intact, and what they will do next". Like Wisniewski, he doesn't see the LockBit brand surviving as is. "I expect it will either rebrand or disperse into other groups in the way that Conti did. But will anyone want to work with them?"

Perhaps the most important consequence of the NCA takedown is the message it sends. "LockBit is the 800lb gorilla in the ransomware world," Stockley said. "If law enforcement can tackle LockBit, they can tackle any group. This won't stop ransomware, but every ransomware group is going to look over its shoulder and wonder if law enforcement has already infiltrated them, or any other groups they work with."

However, as Adam Marré, CISO at Arctic Wolf and a former FBI agent investigating cybercrime, warned: "Last year Arctic Wolf identified how the new ransomware group Akira had risen from the fallout of the Conti ransomware in 2022. Given the dispersed nature of LockBit, it is also likely [that] threat actors who aren't involved in any follow-up arrests will still make use of the existing infrastructure not affected by this activity."

I also thought it was interesting that it would appear LockBit was taken down by law enforcement agents infiltrating their networks using a known vulnerability in the same way that LockBit associates infiltrate their victims.

"Operation Cronos gave LockBit operators a taste of their own medicine," Huseyin Can Yuceel, a security researcher at Picus Security, said. "According to LockBit admins, the law enforcement agencies exploited CVE-2023-3824, a PHP vulnerability, to compromise LockBit's public-facing servers and

gain access to LockBit source code, internal chat, victims' details and stolen data." This has been picked up by contributors to some of the dark web's Russian-language criminal forums, where other threat actors have spoken of the bad operational security from LockBit that allowed an unpatched vulnerability to take them down in such a high-profile operation.

But wait, there's more. Over to Brian Higgins, a security specialist at Comparitech. "It's a win for the good guys, but it's no reason to let down your guard or cut your budgets," he said. "The best thing to do is follow the story, read all of the press releases and reports to find out how you can use any publicly released intel to target-harden your organisation or business, and learn from the methodologies and protections that may come to light."

Ryan McConechy, CTO of Barrier Networks, concludes that this should involve "training on threats, implementing MFA to secure employee credentials, keeping systems up to date with patches, and getting a well-oiled and comprehensive incident response plan in place, so everyone can step straight into effective action, even when attacks do occur".

Ransomware-as-a-service model remains atop the criminal strategic tree

LockBit operated on what is known as a ransomware-as-a-service (RaaS) model. This is a modus operandi that has become dominant in the world of ransomware groups as it leaves the creators of the ransomware software, the cyber-kingpins if you like, a few steps removed from those actually undertaking the attacks.



ABOVE "It's a win for the good guys, but it's no reason to let down your guard"

"Operation Cronos gave LockBit operators a taste of their own medicine"

BELOW The NCA, the FBI and Europol joined forces to infiltrate the LockBit network

By using affiliates or associates, recruited through criminal dark web forums and usually highly vetted before acceptance, the creators hope to separate themselves from the dirty work and reap the rewards. Well, some of the rewards: the affiliates often get the lion's share of any ransom paid.

The affiliates get access to the ransomware malware, which the main group maintains and evolves, as well as a control panel that can include additional methods of applying pressure on victims, such as the publication of stolen data to the "official" leak site and launching denial of service attacks. These affiliates often employ the use of third parties themselves, notably initial access brokers, to purchase details of organisations with known vulnerabilities that can be exploited or which have already been compromised with stealth malware.

Brian Boyd, head of technical delivery at i-confidential, says that "ransomware-as-a-service means targeting smaller organisations with smaller ransoms can become a force multiplier". It also means that attacks can be carried out with relative ease. "Criminals have box-packed tools that make it easier than ever for novice criminals to launch devastating attacks," said Boyd, adding that organisations of all sizes should boost

their defences against ransomware. "Otherwise, with the prevalence of RaaS models, we could be seeing even higher numbers in the year ahead."

Dr Evil does ransomware

Sticking with the ransomware theme, a fascinating report came my way courtesy of Chainalysis,





Continued from previous page

namely the Crypto Crime Report for 2024 (tinyurl.com/356chain).

Now, ordinarily, anything that mentions cryptocurrency raises red flags for me as it's often yet another over-hyped marketing fluff job in disguise. But this one was different: it had substance, and it looked at cryptocurrency payments received by ransomware groups.

Two headline statements stood out for me: that 2023 was the worst year on record when it came to the amount of crypto payments paid to ransomware groups; and that the total amount broke \$1 billion for the first time. I feel like I should have my pinky finger on my lip, Dr Evil style, as I type this, but yes, you read that right, one billion dollars in just one year.

To put this into context, in 2022 Chainalysis reported a figure of \$567 million in ransomware payments, largely down to the success of law enforcement takedowns. In 2021, for example, the number had drawn perilously close to the billion at \$983 million. What impact the LockBit takedown will have on the 2024 totals remains to be seen, but 2022 apart the trend has been upward since 2019.

The report looks to big-game hunting groups as the reason for the rise in overall ransom payments, with Clop and LockBit (and others) taking down some very big names with very big, multi-million-dollar ransoms as a result. Sure, as Brian Boyd mentions, these trophy targets are not the be-all and end-all of ransomware, and smaller organisations can't afford to let their guard down, but groups carrying out such attacks are looking to maximise profit and minimise risk. The fewer the targets, the lower the risk of getting caught.

However, the flip side of this particular criminal coin is that by going for bigger targets, there are more resources poured into hunting down the perpetrators. As the report states, one thing is for sure: "Overall, big-game hunting has become the dominant strategy over the last few years, with a bigger and bigger share of all ransomware payment volume being made up of payments of \$1 million or more."

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STEVE CASSIDY

"That the agriculture in question was a vineyard had nothing to do with my interest"

After a pun-rich visit to Hungary to see agricultural drones in action, Steve shares his many frustrations with NVMe storage

A last-minute invite from a firm of Hungarian drone makers was just what I needed in the depths of winter. An invite made all the more intriguing by the fact this was a new company in the midst of a geopolitical area hosting the first drone war, even if the subject of our presentation was drones in agriculture. That the agriculture in question was a vineyard had nothing whatsoever to do with my interest.

From a tech perspective, most of the demos were basic. The drones looked like an upside-down ride-on lawnmower, except with a watertight compartment where the seat would normally go. A double-glazed window was enough to make their hovering shapes silent and a trifle ominous against the cloudy, snowy sky that day.

These beasts were built for delivering precise amounts of the right kind of insecticide to crops, of which vines and grapes make an excellent example. In part because ABZ Drone, the Hungarian company in question, has figured out how to make best use of the rather turbulent environment in the vicinity of a drone, directing the payload by making minor trim adjustments to the hover motors. There's a Goldilocks zone in this job, outside of which too much expensive medicine is shot all over the field.

The problems in this field (sorry) stem (ouch) from pretty much every area of drone handling. The machines will run for an hour or so with a full load of whatever-icide on board, but the bit we didn't see on the day was the software that glues together the output of chemicals to the single square metre of ground the drone is flying over at that instant. This is kind of important. One point of the drone is to not



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"The demos were basic. The drones looked like an upside-down ride-on lawnmower"

BELOW Drones are able to deliver precise amounts of insecticide to crops in the field

expose humans – or, indeed, other plants or animals – to the stuff the flying machines are dispensing. It's hard to do that when you need to be within line of sight of the target area, so you can actively fly the drone.

This is where I see the future solution: digital twins. Most of the time, we think of these as being gargantuan collections of data: every possible collectible snippet about the thing you're working on, whether that's a computer, a suspension bridge, a field or a fishing ground. Famously, when Lenovo made a digital twin of its own workstation PCs, the project was so huge that the resulting digital model was too big to run on the machine it portrayed.

For a lot of people, the promise of a digital twin is that it expresses absolutely every measurable thing around a large real-world object. However, there's no rule that says you can't start small, much like those wireframe animations from the late 20th century. In the case of farming, record the essential facts using your sensor-equipped scout drones, which can then be read as a smart flight plan by your insecticide-equipped "warrior" machines. Extra data can always be added later, and in the case of agricultural digital twins, you'd be



expecting to re-scan, re-fly and re-spray several times in a growing season, because the messy old real world out there is going to keep on invalidating your earlier findings.

I can soon see a time when a fleet of drones can survey a space, take samples here and there, and come up with an optimised plan for planting, spraying and harvesting based on a general digital twin of “nature” plus localised mapping, and some objectives from the farmer. This sensor drone fleet might be something you hire by the day, while you buy and keep the spreader drones.

I know what a lot of readers will be wondering: is this a company with any military drones in the shadows? Could this technology be militarised? To which my response is no to the first and yes to the second. ABZ didn’t seem to be much distracted by the prospect of militarised drones taking over the “civilian” economy or affecting its business at all.

But then, from looking at its product ranges and talking to its developers, it seems clear that ABZ’s agricultural drones can generate so much better long-term returns (and use less pesticide) than the old ways of doing things that there’s plenty of money to reap. Even more so when it moves from human pilots to AI, which won’t be long off if you think of it as an exceptionally small digital twin exercise. ABZ’s website has to be translated from Hungarian, but for more check out tinyurl.com/356drone.

NVMe: not very me

I can’t decide whether I got into NVMe solid state drives very early or very late. I still have (and even sometimes use) my super-ancient Toshiba laptop, equipped with a PATA-to-CF card converter board, which boots Windows 98 very, very quickly indeed. My posh camera is a Nikon D3, which connects to a Mac PowerBook G4 equipped with another PATA card. Both of these conversions rescued dead machines and gave them an incredibly long future life, and they set the scene for me fiddling about with storage upgrades in various laptops, desktops, servers and even tablets.

If the mysterious red plastic object in the picture on the right is unknown to you, then I can categorically say you’ve not done an SSD disk upgrade to a modern, metal-plank iMac. A challenging process, to be sure, but easily mastered with the assistance of this



suction floor-lifter, which I bought from eBay for £13. I couldn’t find it on the site any more, but you can buy something similar from Amazon for around £7 (tinyurl.com/356sucker).

I was quite happy with the simple world of SATA SSDs in the years that followed. The 2.5in-long metal casing often includes little more than air around an improbably small group of chips, but the performance gains were so significant that people ignored the shorter life than the earlier generation spinning disks could proffer. Being confident about the broad applicability of the 2.5in SSD was a large part of its advantage. Sure, some machines might not recognise certain makes or models of drives, but early issues like that were swept away in a tidal wave of oversupply, tumbling prices and uber-nerds posting YouTube videos of the boot times of their laptops.

Having done so well with the first-generation architecture upgrade, I had a terrible series of experiences trying to adopt the NVMe/M.2 SSDs. I noticed that a few of the machines I bought had promisingly empty chip sockets under their drive hatches and RAM doors, but quickly discovered that just because a PCI-E storage device fitted into the connector didn’t mean that it was going to be seen or made usable by any other parts of the device. So I wrote off the whole architecture and went back to my SATA cables, cursing those manufacturers who didn’t turn on the RAID features of their motherboard chipsets from the factory.

ABOVE Upgrading to NVMe SSDs has often been a cause of pain

“I was rescued from this technological dead end by a chance chat with an IBMer”

BELOW So long, sucker: an essential tool for an SSD upgrade in an iMac

Hacking about with storage controller drivers to change from single-drive legacy mode over to multiple disks and pre-boot RAID configuration BIOS screens was not a terribly safe procedure. Not a problem here, but certainly more difficult to package up in advice to clients and readers.

I was rescued from this technological dead end by a chance and informal chat with an IBMer. Not a Lenovo person: a real, true old-school IBM server person. He wanted me to see the strange, mixed-up set of motherboard RAM slots in IBM’s latest server. These were entirely flexible, he said; you pick the mix of storage and working memory you want and the server builder gives you mixed-use DIMMs, split between RAM and SSD functions. Even today, that sounds like science fiction, and I was somewhat ashamed to say it didn’t really look that impressive. A few more wires, some inoffensive looking chips, and almost no drama whatsoever.

When one sees something unassuming in IT, one has to tread with some care. Right enough, several years after that sneak peek behind the scenes, we’re in the middle of a huge storage revolution, mostly predicated on fixes for the issues I hit, cursing at eviscerated laptops in my basement workroom, and somewhat driven also by the “box of fresh air” criticism of SATA 2.5in SSDs.

We are now well and truly in the age of NVMe storage.

The basics of NVMe are that the storage chips are physically very small, very low power and with only a



moderate level of support chips for connections and storage operations. I've been buying servers and setting up RAID's for three decades now, and I can remember paying £1,500 for a single RAID controller expansion card. This makes it quite challenging to make the adjustment down to the Axagon PCEM2-1U (tinyurl.com/356axagon), which I found for under £20 online while researching storage options for my revived Mac Pro workstations. It looks more like a blanking plate from the Pentium II era than it does a storage expander running many hundreds of times faster than your average PC's onboard storage connection.

A screw loose

There is, however, a small problem here. That dirt-cheap purchase price covers a spare mounting screw (so small, it's lost already), a tightly folded multilingual wad of use instructions, two plastic bags and a short strip of mid-blue heatsink tape. At least, I think it's a heatsink – it could equally be an insulator. Make a sandwich of the blue tape, the PCI slot header and your NVMe SSD, and in theory that's you up and running.

The devil is, as always, in the detail. NVMe as a connection standard is almost literally brain-dead: the PCI Express attachment and conversation is handled by your SSD. In essence, NVMe just says "get out of the way" in places where I have come to rely on adding more brains, not removing them. Okay, so it makes the crucial bit of minimal enabling hardware remarkably cheap, but I'm not sure I actually want to have cheap storage in my expensive computers.

Then there's the heat. I found an empty USB-C enclosure with NVMe internal connections, equally cheap, and used it to house a 256GB SSD to hold my travelling data set. No sooner had I started making use of the speed increase from USB-C than the drive started acting up. It wasn't until I remembered that little lost screw that I realised what was going on: the lost screw had been replaced by a tiny folded scrap of tissue paper, between the metal case and the NVMe slot. That scrap alone was overheating something, either in the USB chips of the case or in the NVMe connections of the storage.

Naturally I shall fit a rant in here about absent error messages. After the number of Windows versions we've all been through, someone at Microsoft should have a way of bringing the tribulations of the hardware forward to the eyes of its user. I realise that when flogging £30 gadgets companies have neither the time nor the budget to develop flashy temperature monitors or beeping alert signals – and even when they do, what I mostly seem to be given are warnings about the warning system, not about the basic kit they are monitoring. To me, that's Microsoft's job. But my wider argument is that when buying any equipment for £30 or less, in storage or elsewhere, we have to factor in the inevitable limitations that come from the seller simply not making much money.

My £1,500 RAID card (bought, I think, in early 2001) was a different beast. You could configure the drive arrays in pre-boot phase, provided you had the reflexes to hit the right F key at the right point in the server startup. There was separate management software inside Windows, with the ability to make or destroy drives and arrays. I could even set up inter-server storage clustering, though that struck me as overkill for the application I had in mind. All those extra features are great for a certain type of deployment – one that modern data centres don't make much use of these days. It's easier to treat the entire server as a swappable bit of hardware.

My last grumble about NVMe, I promise, is the overall issue of moving drives around sets of servers. I see that Axagon also makes NVMe enclosures on USB-C prominently identified as "with clone function". This is one of those concepts that only the inner nerd priesthood is truly happy with. Almost everyone else, it seems, doesn't like or trust the idea that one drive could be a bit-for-bit exact copy of another. Even though I'd hazard a guess that I, Davey, Jon, Lee and many *PC Pro* readers have cloned disks now into the many



ABOVE An old, but expensive, Intel SSD was the solution

thousands as part of taking people through a safe upgrade process.

Yet still I come across those who say "I don't like doing that in case I lose my warranty". And, with NVMe SSDs, they may just have a point. I haven't had as high a failure rate on SSD cloning as I have while fiddling with NVMe storage. The best I can tell, NVMe relinquishes a whole lot of drive activity to the machine BIOS, because it simply doesn't want to boost its own chip count to a costly level.

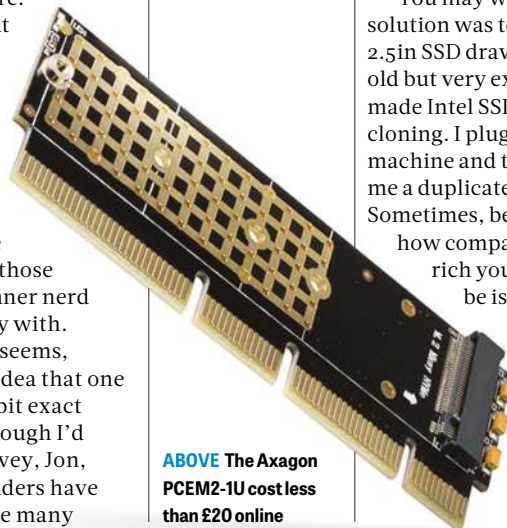
Swapping between my little external SSD box and the internal PCI expander after a disk-clone operation overwriting the NVMe, I didn't get the usual instant flurry of minor expect discovery errors one might expect after a disk clone: I got absolutely nothing at all. It was as if the NVMe chip had never been written to. Put it back in the expander and there were the OS files and cloned settings. Swap back to the other PC and nothing.

You may well have guessed that my solution was to crash about in the 2.5in SSD drawer here, fish out an old but very expensive and nicely made Intel SSD, and drop it in for cloning. I plugged it into the target machine and the clone process gave me a duplicated setup on the first try. Sometimes, being able to nominate

how compatible or how feature-rich your storage systems can be is a much more successful and straightforward path than following the bleeding edge. Perhaps one more generation of R&D and NVMe will be more broadly usable.

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"I'm not sure I actually want to have cheap storage in my expensive computers"



ABOVE The Axagon PCEM2-1U cost less than £20 online

RETRO



Inspirational stories from computing's long-distant past

Emulation stations: ZX Touch vs Anbernig RG35XX H

Always after a retro gaming fix, **David Crookes** puts two leading handheld contenders through their paces in a head-to-head test

Gaming on the go has proven popular for decades. The Milton Bradley Microvision was the first handheld system to have interchangeable cartridges when it was unveiled in 1979. The 1980s saw the release of many Nintendo Game & Watch devices alongside a host of other single-title handhelds by other makers.

In 1989, Nintendo's iconic Game Boy was snapped up in droves, primarily due to its low price and the inclusion of *Tetris*. It went on to comfortably win in a race against Sega's Game Gear and the Atari Lynx. Later, the WonderSwan, Neo-Geo Pocket Color, Sony's PSP and PSP Vita, and the Nintendo DS battled for gamer attention. All go to show that players want to play regardless of where they are.

Supplementing these major releases by big-name manufacturers are loads of handheld retro emulation devices by lesser-known companies – units that put classic games from yesteryear in the palm of your hand. Picking through them all is something of a game in itself. You can find yourself in a Top Trumps situation comparing stats as you pit them against one another.

The idea is that you're able to load them with game ROMs – files that you typically find online. Ideally, you'd own the original versions of those ROMs, because there's no getting around the fact that downloading and/or sharing copyrighted ROMs is illegal. But there's no doubt people do go down certain paths and, if you're a little unsure, you should look instead for homebrew titles and

ROMs released into the public domain. There are lots around.

■ Make your own handheld

You can also create your own retro handheld. If you have a Raspberry Pi, consider PiBoy Mini or keep an eye out for the Pimoroni PicoSystem, which makes use of RP2040 and encourages you to code your own titles. You might also want to check out the Playdate; it's not a handheld retro emulation

system, but a retro-inspired, black-and-white device that's popular with indie developers and it features a mechanical crank as a rather novel input.

Here, we're going to look

at two very different emulation-based handhelds: one expensive, one cheap; one capable of playing games from a single system and one that can run titles across many. It will give you a flavour of the diversity of devices on sale, which also includes Retroird Pocket 2S and Miyoo Mini+. The big question is whether they're worth a go.

“Here, we're looking at two very different emulation-based handhelds: one expensive, one cheap”

BELOW The ZX Touch (left) and the Anbernig RG35XX H (right) are on test



ZX Touch

Not without its quirks, but this is a capable handheld with a fantastic screen that Speccy aficionados will love

SCORE ★★★★★

PRICE £219 inc VAT from zx-touch.com

There have been numerous attempts at creating devices based on the ZX Spectrum and some have proven to be hugely controversial – we're looking at you, ZX Spectrum Vega+, which ran into a heap of trouble and led to a small number of units being delivered.

The ZX Touch shouldn't be tainted with such past woes, however. This is a handheld that began as a project purely for fun rather than to make money. It just happened to be so eye-catching that it was deemed suitable for unleashing on the retro market.

Created by Goran Radan, co-owner of a company called Elmar Electronic in Croatia, the device is an impressive beast. It's a chunky, robust offering with a 7in touchscreen that is a little heavy to hold but not uncomfortably so. On one side there's an analog stick and a four-button D-pad; on the other are four input buttons and a speaker.

One thing that strikes you straight away is the grey colouring. Compared to the actual ZX Spectrum, it looks a little too functional, almost crying out for the rainbow splash that helped to make the original stand out from the crowd. At first glance, it seemed the only real way to note its link to the iconic machine was the colouring on the ZXT logo. It all felt too subtle.

But then we switched it on. It burst into life in an instant, colours flashing through the transparent sides, lighting the immediate vicinity with red, yellow, green and blue.

The ZX Touch has an attractive front end, and it doesn't take long to figure out how to navigate it. When you want to play a game, you just need to tap a title's thumbnail. You then tap Start to get stuck in.

There are 22 games pre-installed, all of which have been written by Speccy enthusiasts. They give you a flavour of what the ZX Touch can do and they allow you to start enjoying some fun games that you may otherwise not consider trying.

For the price, however, we did wonder if the developers should have sought to license at least a handful of commercial games. As it is, you're left to source your own ROMs, although that's generally par for the course when it comes to emulation devices. The good news is that adding ROMs is straightforward: whack a load of TAP, SNA or TRD files on to a microSD card, insert it and the ZX Touch can sort the rest (if you have a TRDOS ROM on the card, anyway).

There's also something else you'll have to consider. Flick through the 24-page A5 manual (which contains a few spelling mistakes) and you'll come across a section that suggests sourcing and adding the original ROMs from the ZX Spectrum 48K and ZX Spectrum 128K computers if you want to ensure full compatibility with the platform's games.

It goes on to say that you can find these online or bundled with various emulators but, while it's only a minor

ABOVE The superb 7in screen displays games as they were intended to be seen

"It's a bare metal emulator using software that has been developed from the ground up using pure C/C++ code"

inconvenience, it does mean it's not an entirely out-of-the-box experience.

In a sense, such gripes can feel too negative, overlooking the otherwise sterling work that has gone into the creation of this device. For starters, it doesn't simply grab an existing emulator. Instead, it's a bare metal handset using software that has been developed from the ground up using pure C/C++ code running on a high-performance ARM Cortex-M7 580MHz MCU.

The handheld has been created with the specific needs of the Speccy in mind. Since many games require text input, there are a set of keys to the left and right of the central part of the screen. You can, if you wish, remap or remove these by delving into the settings, where you'll also be able to toggle many other aspects of the display, sound, side lights, joystick and more. One thing we did find is that after effectively turning off the side lights by reducing the brightness,

they shone bright once more when we turned the handheld off and on again.

The main thing, though, is how well the games play, and on that score we've been more than pleased. The buttons click satisfyingly

and are very responsive, the analog stick is comfortable and the large screen, which works at a 50Hz refresh rate, ensures scrolling is smooth and that the text displays perfectly.

Sound is a tad ropey in places and there are no physical volume buttons, which is an oversight (you can turn off the sound via an on-screen icon). Yet the device still mimics the blips and beeps of the original system and it really does take you back in time. With promised firmware updates and continued support, we expect many niggles will end up being ironed out.

The big question is whether or not all of this is worth £219: a price that doesn't include shipping or even a USB-C charging cable. Yes, you're getting a large screen and a well-built, highly configurable device but, at the same time, it's dedicated entirely to one system. You're going to really have to love the Speccy, we reckon, but then so many do.



LEFT All of the 22 pre-installed games have been written by Speccy fans

Anbernic RG35XX H

This well-made, versatile device can emulate games made for a host of platforms, including PlayStation and PSP

SCORE ★★★★★

PRICE \$68 from anbernic.com

Anbernic's RG35XX H is at the other end of the spectrum to the ZX Touch, if you pardon the pun. It's inexpensive and it allows you to play games across a host of platforms. It's also a tad smaller, making for a more pocket-friendly device.

Like the ZX Touch, it uses a horizontal format, placing the buttons to the left and right of a central 3.5in 640 x 800 screen. There's a four-directional D-pad, four input buttons and dual analogue sticks. Capable of emulating games created for over 30 different platforms, it's powerful enough to play games developed for the PlayStation, PSP and Dreamcast.

The latter point is also true of another notable Anbernic device, the slightly cheaper RG35XX Plus. As you'll see, there's a similarity in their names because these two devices are identical internally, both making use of a H700 quad-core ARM Cortex-A53 CPU and a dual-core G31 MP2 GPU.

The big difference is that the Plus closely resembles the Nintendo Game Boy in appearance, something that seems to inspire other Chinese manufacturers of inexpensive handheld consoles. But while that screams retro and makes the Plus very attractive to those who want to steep themselves in nostalgia, the H (which stands for horizontal) takes the gaming experience to another level.

There's nothing inherently wrong with the Plus. Held vertically, it places the 3.5in screen up top and the main play buttons at the bottom. You get the D-pad to the left, input buttons to the right and Select and Start buttons at jaunty angles in the centre, along with a Menu selector. There are also left and right shoulder buttons at the back.

If all you want to do is play games up to 16-bit, it will do the job. You'll find it easy to get to grips with Game Boy, NES, Game Gear and Game Boy Advance games along with those made originally for the SNES and Mega Drive.

But as you move towards the more advanced platforms, you'll likely become frustrated. The shoulder buttons begin to feel awkwardly placed and, with no dual analogue sticks, navigating some games can

become a chore. The RG35XX H addresses these concerns. Its shoulder buttons are in better reach and you can twiddle your thumbs on well-placed sticks. By pushing your hands further apart, the device is altogether more comfortable to use.

This degree of care and attention extends to the entire package. Though it arrives in a small, no-frills box, the handheld is covered with padding and it comes with a screen protector, a USB-C charging cable and a manual that details all you need to know. You can insert up to two microSD cards on which game ROMs can be added: ensure they're FAT32-formatted, insert them into the device to create folders automatically for each platform and use the storage with your computer to copy ROMs over.

Booting the Linux-powered device takes about 15 seconds, landing you on a basic-looking homescreen. From there, you can select Game Room to launch a standalone emulator or RA Game to launch RetroArch, a free, open-source front end. In either case, you'll get access to many different emulated systems and, by selecting one, you'll see a list of games.

To play, it's a simple case of clicking on a title. The game will load very quickly and make full use of the sharp, colourful screen. If you like a particular game, you can go back to the list, press Start and star it, saving it to a Favourites section on the homescreen. There you'll also find a history section, a search button to allow you to quickly find games without having to endlessly scroll through a list, and a host of settings, letting you play around with the backlight, backgrounds and more.

The games themselves play identically to those running on the original systems for the most part – certainly when enjoying games made for the 8-bit and 16-bit systems, machines that modern technology is more than capable of emulating. They run at the correct speed, with

ABOVE You can play loads of homebrew games on the RG35XX H

BELOW Insert headphones and connect to a TV for big-screen action



few to no glitches, the D-pad works well, the face buttons are responsive and the dual-sticks, if you use them, are fluid. Indeed, the entire device, despite being made of plastic, feels satisfyingly robust.

The experience goes off the rails a little when you start playing the more advanced systems. While you'll find PlayStation games work very well, the same can't always be said of titles made for PSP and Dreamcast; these are really pushing the limits of the device. A lot depends on what you're playing and how processor-intensive it is, but if you see the addition of these systems as a bonus and don't buy it solely to enjoy your catalogue of Dreamcast games on a small screen, you'll be more than satisfied.

After all, what the Anbernic RG35XX H shows is that you don't have to spend a fortune for your on-the-go retro gaming fix. With this device, you can play for up to eight hours on a single charge, enjoy most games as they were intended to be played (complete with vibration motion if the developer included it) and, if you wish, even connect the device via HDMI to your TV for big-screen gaming (it's also possible to connect a wireless gamepad to the device using Bluetooth). You can even enjoy online

multiplayer over Wi-Fi with this particular device.

As time goes on, we expect the device to get even better. As well as firmware updates (one has already added support for Atari consoles), the

gaming community is sure to create mods just as it did for the older RG35XX – GarlicOS (tinyurl.com/355garlicos), for instance, is a superb, popular upgrade. The fact that people are willing to invest such time and effort shows just how fun these devices can be. ●

"To play, it's a simple case of clicking on a title. The game will load very quickly and make full use of the sharp, colourful screen"

Futures

We explore the trends and technologies that are set to shape the future

The robot dog leading blind people

University of Glasgow researchers have created a robotic dog to help visually impaired people tour a museum – and they can even ask it questions. **Nicole Kobie** explains how it works



We're used to seeing dogs help blind and partially sighted people navigate the world. But normally the dogs are real. Researchers at the University of Glasgow have developed a system to put robot dogs to work for visually impaired people, helping them explore a museum and offering information about the exhibits.

In the UK, more than two million people suffer sight loss of some sort, of whom 340,000 are registered as blind or partially sighted. Most people with sight loss are over the age of 65, and the number of people with sight loss increases each year; it's set to double by 2050, according to the Royal National Institute of Blind People (RNIB). Most of those people will need some assistance navigating their daily lives.

"Mobility is a big issue for the blind and partially sighted community," said Jackie Winning MBE, chief executive of the Forth Valley Sensory Centre, adding that new technologies can "improve the independence and confidence of people with sensory loss

and make sure they can live their lives to the full". Indeed, only one in four blind or partially sighted people are employed – a figure that the RNIB says hasn't changed for a generation.

To help, researchers are turning to off-the-shelf technologies like smartphones, as well as advanced tools such as robots and augmented glasses, to help blind people find their way. The Glasgow-based academics decided to make a seeing-eye dog for indoor spaces, including museums, shopping centres and hospitals. The first trial was at the Hunterian, where RoboGuide navigated the museum's ground floor and offered interactive audio information about six exhibits.

■ From humanoid to dog bot

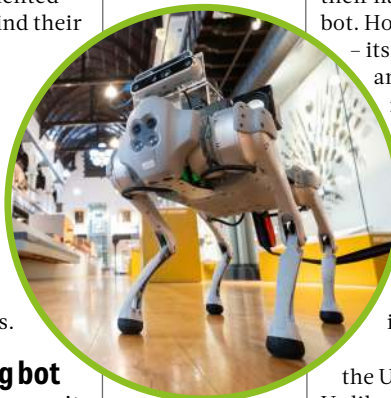
The first version of RoboGuide wasn't in dog form, says Dr Wasim Ahmad of Glasgow's James Watt School of Engineering. The robotics department instead used a Pepper robot, a rolling,

humanoid model. Ahmad says he had in mind how blind people navigate in other parts of the world, with their hand on the shoulder of someone walking ahead, rather than a guide dog.

So the team designed systems for Pepper to act like a human guide, with a blind person following along with their hand on the five-foot-tall rolling bot. However, Pepper has limitations – its wheels struggle over carpet and it can't climb stairs – and the

researchers wanted to develop a system that would work in any robot, so they tried a different model. "We wanted to prove that the robot itself is not a limitation," Ahmad told *PC Pro*. "The technology is portable, it can be integrated into any type of robot."

They turned to a robot dog, the Unitree Go1, which costs \$2,700. Unlike the wheeled Pepper robot, it can climb stairs and isn't put off by carpet. Many blind people are also accustomed to working with a seeing-eye dog – indeed, the RoboGuide uses



ABOVE The RoboGuide is able to navigate around the Hunterian Museum in Glasgow



LEFT A robot dog could be a life-changer for people unable to keep a real guide dog

the same harness as such a dog, which is one way the user is led along.

Why not just use a real dog? While there are additional costs to program the system, the price of the robot is far cheaper than the £3,000 cost of a guide dog puppy plus tens of thousands to train one (although the Unitree dog is less cuddly). There's also a shortage of guide dogs, meaning many people go without. "One motivation for us was that we should have technology play a role in accommodating some of these users," Ahmad said. "If a person can't get a dog for a month or in the long

term, this can fill the gap."

And some people simply can't have a dog, whether that's due to a fear of dogs, a lack of suitable accommodation or allergies. Indeed, Ahmad says the team is meeting with one

blind person who currently uses a seeing-eye horse for that very reason.

Dr Olaoluwa Popoola of the James Watt School of Engineering adds that they want to enhance visually impaired people's senses, not just help them find their way around the house. "It's trying to extend the way a blind person will perceive their environment," he said. "It can help you map out [an unknown] environment in your head."

For example, in the future, a user could search online for a post office, and ask the RoboGuide to take them there. The robot would navigate using Google Maps to find the location, looking for obstacles along the way.

■ How RoboGuide gets around

RoboGuide needed two key features: guidance and navigation, as well as the ability to communicate. When developing RoboGuide, it was clear the system needed a navigation system that didn't rely on GPS. Though GPS works well outdoors for satnav in cars and on mobile phones, it isn't accurate enough indoors.

Way-finding software developed by the team unpicks the best route between exhibits in the museum. Those systems, known as simultaneous localisation and mapping algorithms (SLAM), help the robot find its way – essentially indoor satnav. "When the robot goes into an unknown space, it learns while it's trying to navigate the space for the

Other guide dog replacements

There are other ways to get around when blind without a robot dog – or an actual dog – leading the way. The use of GPS for blind navigation goes back to the 1990s with the Arkenstone Strider, but the advent of smartphones made it possible to add such features with an app rather than a standalone device.

One recent technology is RouteNav, an iOS app designed by researchers at the University of California, Santa Cruz, to help blind travellers navigate a transport hub. Rather than use Bluetooth beacons – which ping devices to help pinpoint locations – RouteNav uses GPS. But as the signal can be weak indoors, the researchers paired GPS with a dead reckoning system that breaks the space into "tiles" to plan a route and track progress.

In tests at the Palo Alto Transit Center in California, blind participants navigated three routes from trains to buses and vice versa, covering an underground tunnel, boarding areas and finding a gate in a fence. Similar apps include Identifi, which helps users navigate inside using AI image recognition, and Blind Square, which reveals road names and shops as you walk by them.

Microsoft Soundscape was another phone-based tool. This used sound to describe what a person was walking past, letting them better find their way – perhaps calling out a saved location as the user walks by. However, it was discontinued in 2023.

Researchers at the University of Technology Sydney in Australia also looked to sound to help visually impaired people navigate the world, building smart glasses that make a noise when

specific objects are seen by the computer vision system, with AI processing the data to identify whether that's a bowl, cup, book or bottle. For example, when the glasses "see" a book, the sound of a page turning is played to notify the wearer.

Be My Eyes is an app that allows blind users to ask for help from volunteers via photos or video calls. So far, the app has been used by 19,000 blind and partially sighted people, assisted by 6.9 million volunteers. A new version, Be My AI, is set to arrive soon using OpenAI's GPT-4 to understand requests and describe a picture to a blind user.

The developers say the AI-powered version could be used to read text – such as instructions or magazine articles or WhatsApp messages – or to choose the right colour combinations for an outfit. Even to select the right buttons on appliances such as a dishwasher and to navigate using signs in transport hubs. One similar app is TapTapSee, which uses cloud-based image recognition to identify objects, while Ask Envision also uses OpenAI's technology to describe images and text and read them aloud for blind people.

And then there's Ximira's PHINIX (Perceptive Helper with Intelligent Navigation and Intuitive eXperience), unveiled at CES 2024 (see issue 354, p26). Worn as a backpack, this system uses cameras and headphones powered by a laptop motherboard to analyse the world around a wearer with AI and describe it to the wearer – it even has facial recognition to help spot friends.

In short, technologies such as smartphones and AI are being used to help blind people better understand the world around them. And soon they might have the option of a robot dog, too.



first time," said Popoola. "It learns about its environment."

The RoboGuide must also react to new objects in the space, be it a chair in the room or a person walking around. "There is a collision avoidance algorithm that we also introduced in the system," Popoola said. "We implemented that with a combination of Lidar and RGB cameras."

He explains: "By combining the intelligent mapping strategy with the collision avoidance algorithm, we're able to get this expected goal that we want for the robot to move around and not collide with objects and safely navigate to a particular location."

A RoboGuide can share information via the cloud, so that if one learns a space, all of the others will, too.

■ The guide in RoboGuide

Users need to be able to communicate with RoboGuide. To enable that, the researchers embedded a large-language model, so a blind person can verbally tell the dog where they'd like to go next, and the robot can respond.

For the trial in the museum, the researchers relied on the Unitree robot's built-in microphone and speakers, but found that it was often too noisy in the room, so users had to shout to be heard by their robot dog. In the future, they're hoping to use a headset for clearer communications.

The AI-powered communications also allow the RoboGuide to do one trick that fluffy seeing-eye dogs can't: answer questions about the Hunterian's collection. There's no point getting to a display and not knowing anything about it, after all. "It has the ability to go to the internet, find information, and share it with

the user," Popoola said. That's an even better trick than "roll over".

Developing such a system doesn't just require technical skills. To ensure these robotics work for partially sighted people, the researchers have for many years worked with the Forth Valley Sensory Centre Trust (FVSC) and the RNIB Scotland to better understand precisely what blind people need from such tools.

"We have been in continuous contact with our end users," said Ahmad, adding that this principle of co-design is key to developing technology that works for those who will eventually use it, rather than merely what appeals to engineers.

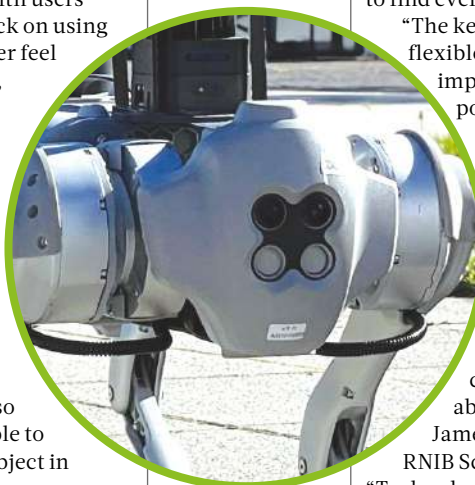
Volunteers from those groups also helped test the RoboGuide at the Hunterian, putting the robot dog through its paces. Overall, the feedback was positive, with users offering practical feedback on using a more rigid leash to better feel where the dog was going, having that headset for sound rather than using the built-in speaker and mic, and including manual controls, particularly for speed. "Instead of just starting to give historical information, it should ask if the user is actually interested," explained Ahmad, saying testers also wanted the robot to be able to physically describe the object in front of them.

■ What's next?

The systems developed for this robot dog should apply to other robot

ABOVE K9 capers:
the RoboGuide has a number of advantages over real guide dogs

"It has the ability to go to the internet, find information, and share it with the user. That's an even better trick than 'roll over'."



ABOVE The robot uses Lidar and RGB cameras to avoid collisions

systems. Ahmad said the project aims to try different form factors to offer users a wider range of choices – after all, not everyone wants a dog, robot or otherwise. Researchers also want to develop their own robot that will be cheaper than the current robot dog.

Popoola says RoboGuides could be used in different ways. They could be outright owned by a blind user, or

rented temporarily under a subscription model. This way, the user has constant access and can use the bot in their day-to-day lives. But RoboGuides could also be owned by businesses

as an accessibility tool, perhaps helping blind visitors navigate a museum like the Hunterian or assisting visually impaired shoppers to find everything on their list.

"The key thing is to have these flexible options, as we want this impactful project to go as far as possible," said Popoola.

Reworking robots for accessibility is a potentially life-changing way to use cutting-edge technologies such as robotics, AI and sensors. If successful, it could give blind and partially sighted people more confidence as they go about their daily lives, said James Adams, director of RNIB Scotland, in a statement.

"Technology innovations like this are reshaping the future of accessibility, and this partnership demonstrates their burgeoning potential to create a more inclusive world." ●

PC PRO

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Labs

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Retro



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The Network



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Futures



AI UK 2024

Nicole heads to the Alan Turing Institute for its AIUK 2024 conference to pick out the latest developments and trends, as predicted by the country's brightest minds.

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A lack of joined-up thinking is driving Jon Honeyball round the bend

Isometimes wonder about the competency of our ruling classes. I don't mean His Maj, but rather the governmental departments tasked with keeping society going.

This applies especially to the administration of private transport. I get that competition supposedly promotes a better service at a keen price – but local and national governments seem very ready to define vague specifications, then hand systems over to outside firms with no real competition. They then find themselves spending a huge amount of money supporting said firms when they can't make a profit. Topped off, of course, by blame-shifting when things aren't as rosy as promised.

Take the Dartford Crossing, which opened in 1991. The original plan, as announced by Tony Blair in February 1999, was that toll charging would end in 2003 after the bridge had been paid for. Shock horror, that didn't happen: instead, the toll was simply renamed to a C-charge from April 2003. It still applies today, and following the introduction of an automatic number plate recognition system in 2014, you can now only pay via the gov.uk website at tinyurl.com/356dartford.

Also in 2003, London introduced its own congestion charge, cleverly using the same logo as the C-charge for the Dartford Crossing even though they're two separate systems. London's congestion charge now covers both access and emissions-based charging, and is also hosted on the gov.uk website, at tinyurl.com/356ccharge.

What if you want to drive into Bath, Birmingham, Bradford, Bristol, Portsmouth, Sheffield or Tyneside? You need to pay for their respective clean air zone schemes, and again you can do this at the gov.uk website: tinyurl.com/356clean. Even if you're not travelling in any of these places, everyone needs to tax their vehicle,

and this too can be done at the same place: tinyurl.com/356roadtax.

Since all of these schemes are hosted on gov.uk, any reasonable person would assume you could set up a single account for yourself, add the registration numbers for your vehicles to that account, and make payments as needed. That would be efficient and logical – but alas it would be far too easy. In fact, each of the schemes I've mentioned above has its own independent payment system. I have to have an account for the Dartford Crossing, another for the London congestion charge and ULEZ, plus an entirely separate payment system on direct debit and account for the vehicle tax for my car, van and motorbikes. As for the Bristol clean air zone, there's no way that I can find to register for a private user account, so every trip must be paid for as a one-off. This is despite all of these systems being hosted on notionally the same website, and all relating to the movement of the same few vehicles.

I have to ask the obvious question: why? What Sir Humphrey has decided that these local schemes are better off doing their own thing, rather than focusing on efficiency – for either the user or the services themselves?

Whatever the reason, we've ended up with a government website that nominally brings things together but which, in reality, is a disparate mess. There's clearly been no push for coherence and efficiency because – I can only assume – everyone has a finger in a different pie. Why tie into one account-management system when everyone can have their own to play with?

And it doesn't end there. Try parking in almost any town these days and you'll need an app. In the car park I use in Huntingdon, it's MiPermit.

Other apps out there include RingGo, AppyParking (which sounds like a contradiction in terms), PayByPhone, JustPark and doubtless a host of others I have lurking around on my phone. Most of these require their own app and their own registration, with payment card details and so forth – although MiPermit at least allows me to enter my registration plate and use Apple Pay.

This proliferation of parking app services is not competition: it's a pain that doesn't benefit us, the consumers in any visible way. It is high time that someone in government started clamping down on this. The idea that

“What Sir Humphrey has decided that these local schemes are better off doing their own thing, rather than focusing on efficiency – for the user or services?”

“it's all online” conceals a whole lot of wasteful duplication.

Experiencing all of this in one area of daily life makes me wonder how things are in the various government and council departments that I don't interact with so frequently. Are any of these administrative behemoths trying to reduce complexity, or is it all a free-for-all on a project-by-project basis? Does anyone care about the inevitable liabilities and errors that this invites?

Someone needs to be given a big enough stick to make these digital services work for the public. My terms will be a significant six-figure salary, a knighthood and the use of a Russian billionaire's yacht.

■ **Jon Honeyball is a contributing editor to PC Pro. He's going to set up an app store for all these payment systems and demand a 99% fee until they merge. Email jon@jonhoneyball.com**



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